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APHID MOVEMENT AND VIRUS SPREAD IN SEED POTATO AREAS OF ENGLAND AND WALES

ASSESSMENT OF AREAS BY MEASURED APHID MOVEMENT

by M. HOLLINGS*

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INVESTIGATIONS were done during 1950–53 to measure and compare virus spread in the seed potato growing areas of England and Wales, and to develop methods for assessing the suitability of areas for seed production.

At ten representative sites, virus-infected tubers were planted in standard positions in the crops, to give 0·1 per cent leaf roll and 0·1 per cent rugose mosaic (caused by virus Y) in each. Tuber samples were taken twice during the growing season from the three plants on either side of each infected plant, and were grown and inspected for virus disease the following year. Aphid movement was assessed both by the number of alatae caught on yellow cylindrical sticky traps (Broadbent, Doncaster, Hull and Watson, 1948) in the crops, and by the index termed the "angle of colonization" (Hollings, 1955). There was a close correlation ($p = 0{\cdot}001$) between the spread of leaf roll and Y viruses to the sample plants, and the estimate of activity of the aphid *Myzus persicae* (Sulz.) obtained by either method.

Because of this close correlation, the assessment of areas by a standardized method of measuring the aphid movement in them appeared to have advantages over a direct comparison of virus increase in the crops. Many of the variable factors affecting the crop—differences in varietal susceptibility to virus, date of planting and harvesting, incidence of virus disease initially present in the crop, and so on—would thus be avoided.

These methods of measuring aphid movement were applied on a larger scale during 1955–57 and, as a check, the spread of leaf roll was measured at many of the sites.

EXPERIMENTAL PROCEDURE

In the 1955–57 experiments, no infected tubers were placed in the crops; the naturally-occurring secondary leaf roll in several representative seed potato stocks in different areas was recorded each year by National Agricultural Advisory Service advisory officers. The proportion of infected plants was estimated by counts on twenty samples, each sample being a length of row containing 100 plants. Where the farmer did not intend to grow on the stock in the following year, samples of 2,000 tubers, taken as far as possible at random, were grown the following year at the School of Agriculture, University of Nottingham, and there scored for leaf roll by Dr. L. Broadbent, Mr. G. D. Heathcote and me.

Aphid counts were made, weekly where possible, at each site—mostly by N.A.A.S. advisory entomologists. The presence or absence of *M. persicae* was recorded on three leaves (one upper, one middle and one lower leaf) from each of fifty random plants. Other sampling methods had shown no advantage over this one (Hollings, 1958). When the percentage of sample plants infested at each count was plotted against time, a curve of colonization was obtained. The slope of a line drawn from an arbitrary zero point of June 1 to the peak of the curve gave the "angle of colonization".

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Only *M. persicae* was studied in the 1955–57 experiments, as the previous results indicated this to be the only important species in spreading virus in the seed areas studied. Sticky traps were operated at 37, 41 and 33 sites in the three years.

Each crop was considered to be susceptible to infection from the date when 50 per cent of the plants had emerged until 75 per cent of the foliage had been destroyed by blight (B.M.S., 1948), or chemical haulm destruction. The degree of isolation of each crop from nearby sources of aphids or virus was recorded. The locations of the sites are shown in the map (Fig. 1).

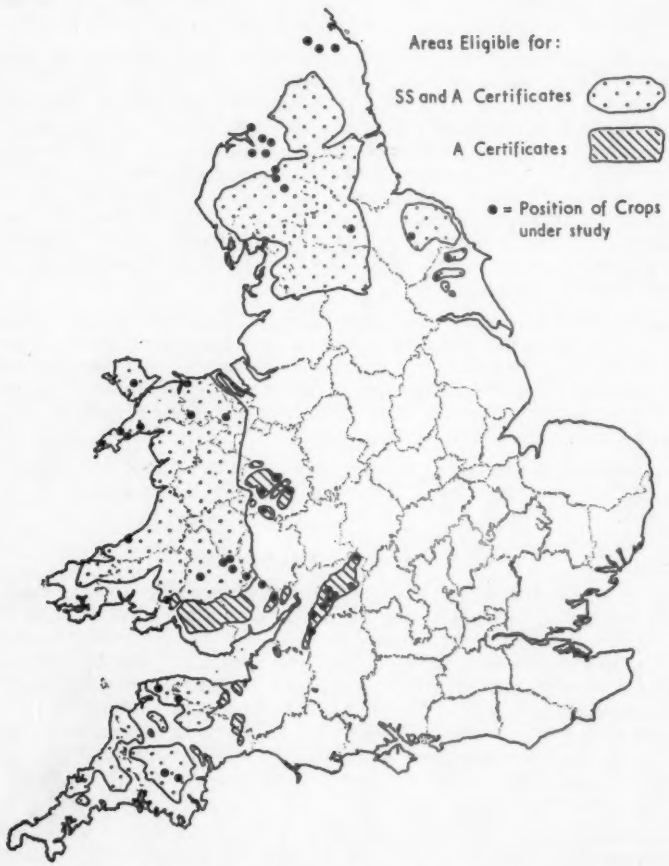

Fig. 1. Location of experimental crops in relation to areas approved for certification.

APHID COLONIZATION

The pattern of aphid infestation differed in the three years. In 1955, *M. persicae* was first detected in the crops in late June in the Cotswolds, Devon, North Wales and the East Riding of Yorkshire. Crops in Brecon and Salop were

colonized early in July. In Northumberland and the North Riding of Yorkshire, immigration was detected during the latter half of July and still later in Cumberland.

Immigration was earlier in all areas in 1956; by mid June, *M. persicae* had been recorded in the Cotswolds, Brecon and Salop; by the end of June in Devon, Cumberland, Northumberland and North Wales, and by mid July in all the Yorkshire sites.

Exceptionally early immigration occurred in 1957, when large numbers of *M. persicae* and other species were flying in the early part of May, often before any potato plants had emerged. By mid May, sites in the Cotswolds, Brecon, South Wales and Salop had been colonized and, by mid June, *M. persicae* had become established in crops in all seed areas. At the end of June, the exceptionally high leaf populations of *M. persicae* declined very quickly (often because of predators and parasites), and did not recover. In all but the best seed areas, the pattern of aphid immigration and build-up during 1957 was similar to that normally seen in a ware area.

Calculation of the angle of colonization proved to be a much more sensitive method of detecting the presence and activity of aphids in seed areas than was trapping; at some sites, quite high angles of colonization were obtained although no alate *M. persicae* was trapped. Considerable spread of leaf roll confirmed that much aphid movement had taken place. But, over the three years, there were only three instances of large trap catches of alatae associated with low angles of colonization.

TRAP CATCHES

Different patterns of movement of alatae occurred in the three years, with differences within, as well as between, some areas in any one year. In Cumberland, few alate *M. persicae* were trapped during the period of growth of the crops; in 1955, on average four *M. persicae* were trapped at each site, mainly during the latter half of August and early September. The 1956 trap catches were twice as great as in 1955, and most activity took place nearly a month earlier.

Trap catches in Northumberland, in both 1955 and 1956, were more than twice those in Cumberland, though only slightly earlier in the season. Much of the exceptionally early migration in May/June 1957 occurred before trapping began.

Insufficient data were available from most of the Yorkshire sites for any general conclusions to be drawn.

Few *M. persicae* were trapped in the Lleyn peninsula of North Wales in 1955 and 1956, while the early movement in 1957 was largely missed. In contrast, sites to the east of the mountains, in Denbigh, had much higher average trap catches.

The small seed-growing region in Salop provided consistently large trap catches in all years—in 1955 the average catch was sixty-three *M. persicae* per site.

Few alatae were trapped in the mid-Wales seed area (mainly Brecon), the average catch being less than 1·3 each year. By contrast, trap catches were high at most sites in South Wales. Only few alate *M. persicae* were trapped in Devon in all years; most of these were dispersal migrants leaving the crop when the haulms were destroyed by blight in late July.

The Cotswolds showed a pattern typical of ware areas; the initial immigration, seldom detected on the traps in the better seed areas, was frequently observed in trap catches. At some Cotswolds sites, catches reached their maximum with the summer dispersal migration in late July and August, but at other sites, immigration was followed by continuous movement of alatae throughout the growing season. The overall average catch was nineteen.

There was a significant correlation ($p = 0{\cdot}05$) between the assessments of aphid movement by trap catches (transformed to the sum of log $(n + 1)$ weekly totals of trapped *M. persicae*) and by angle of colonization, for each site.

CORRELATION OF ASSESSMENTS OF APHID MOVEMENT AND VIRUS SPREAD

Covariance analyses were computed for spread of leaf roll, and the indices of movement of *M. persicae*, during the period (previously defined) when the crop was considered susceptible to infection. The regressions of leaf roll spread on the aphid assessments were also calculated, and are given in Table 1.

Although there is a fairly well-defined overall relationship between spread of leaf roll and angle of colonization, the variation between years is great. This is clearly seen when the regressions of leaf roll spread on angle of colonization for the three separate years are compared: $b = + 0{\cdot}064$, $+ 0{\cdot}032$, and $+ 0{\cdot}083$ respectively. The standard error of the mean of these values ($m = + 0{\cdot}059 \pm 0{\cdot}015$) gives a value of $t = 2{\cdot}32$ (with 2 D.F.), which is not significant at the 0·05 level.

TABLE 1

Regression and Correlation Coefficients of Leaf Roll Spread on Movement of Myzus persicae, *Excluding Variations due to Years*

	b(+)	S.E. ±	r(+)	p
Leaf roll spread on angle of colonization ..	0·061	0·027	0·21	0·05
Leaf roll spread on trapped alatae	0·883	0·48	0·19	0·1*

* Not significant at the usually accepted level.

The overall relationship could, however, be used in another way. Inspection of the data from both the 1950–53 and 1955–57 experiments showed a fairly rapid increase in virus spread between angles of colonization of 55° and 60°; below 55°, virus spread was usually slight, above 60° it was usually considerable. Sites were, therefore, grouped according to angle of colonization: less than 55°, 55–59°, and more than 59°. Each group was then divided according to spread of leaf roll: less than 2-fold, 2–5-fold, and more than 5-fold increase in leaf roll. These three levels of virus spread correspond approximately to those suitable for the production of SS, A and H quality seed respectively.

The resulting histogram (Fig. 2) reveals two main points. First, that some sites with high angles of colonization have little virus spread. This is at least partly due to the roguing done in many stocks before virus counts were made, but may also be due to lack of available leaf roll virus within particular stocks. There is abundant evidence that spread of virus from sources within a crop is much greater than from external sources. The angle of colonization can only indicate the potential virus spread; without adequate sources of infection little spread can occur, and some of the stocks contained little or no virus infection.

Secondly, as angle of colonization increases, so does the proportion of sites with severe virus spread. Only 12 per cent of the sites below 55° showed "breakdown" (more than 5-fold spread), compared with 31 per cent at 55–59°, and 47 per cent at greater than 59°.

TABLE 2

Mean Values for Indices of Aphid Movement and Spread of Leaf Roll in the Different Seed Areas, 1955–57

Area	Average No. of Sites per Year	Angle of Colonization (°)	Trapped Alatae*	Spread of Leaf Roll
Cumberland	7	46	1·17	× 1·7
Northumberland	4	52	1·74	× 1·9
Westmorland	1	58	1·78	× 7·0
Yorkshire:				
East Riding	2	17	1·74	†
North Riding	2	36	0·89	†
Salop	4	66	3·26	× 3·4
North Wales:				
Lleyn peninsula	4	21	0·65	× 1·2
Denbigh	3	32	1·04	× 4·0
Mid-Wales (Brecon)	4	55	0·35	× 2·4
Coastal Wales (Cardigan)	1	43	0·42	× 1·5
South Wales	3	47‡	1·88	× 6·9
Cotswolds	8	65	2·91	×10·1
Devon	4	23	0·80	× 3·2

* Expressed as the sum of log $(n + 1)$ weekly trap catches of *M. persicae*.

† Insufficient data.

‡ Mean reading of 66, 48, 65, 32, 10, 9, 84 and 60°.

ASSESSMENT OF SUITABILITY OF AREAS FOR SEED PRODUCTION

The mean values for assessments of aphid movement and spread of leaf roll, for each area in 1955–57, are given in Table 2. From these results, the sites in Cumberland, Northumberland, Devon, the Lleyn peninsula and the coastal region of Cardiganshire would qualify, both on aphid data and on measured

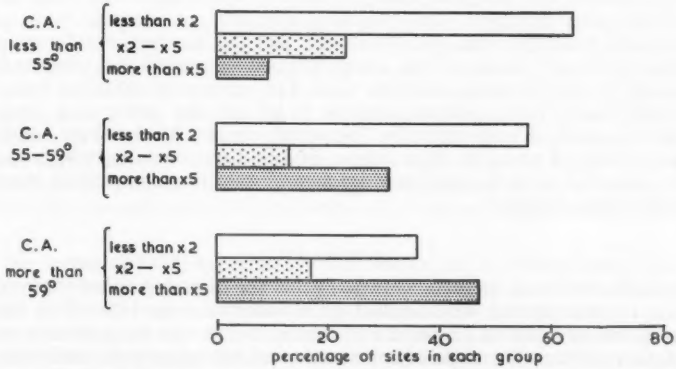

Fig. 2. Grouping of sites according to angle of colonization (C.A.) with groups sub-divided according to spread of leaf roll.

virus spread, as suitable for the production of high-grade seed. The Cotswolds, the Westmorland site, and many of the South Wales sites are clearly unsuitable but, whereas figures for the Cotswolds and the Westmorland site are consistent, those from South Wales are very variable.

The figures from Salop are conflicting, as the aphid indices are very high, but measured virus spread low in field counts. However, on two occasions when tuber samples were taken from Salop sites, both showed more than tenfold spread of leaf roll, whereas counts made on the farms showed much lower figures. It is possible that considerable roguing had occurred, or that symptoms were not clearly visible at the time of field inspections in this area.

Results from the 1955–57 experiments confirm those of the 1950–53 series, with one exception: in the Lleyn peninsula recorded aphid movement and virus spread were considerable in the 1950–53 experiments, but very low in the 1955–57 tests.

Because they are below the 400-foot altitude, several of the Cumberland sites are at present ineligible for SS or A certificates. Both series of experiments show that, apart from the region around Carlisle (and possibly other towns) aphid movement and virus spread are slight throughout the county, and altitude requirements for this district might justifiably be reconsidered.

The variability of results from South Wales indicates that further study is necessary here to show the limits of suitable areas. Further data are also needed from Yorkshire sites. In the East Riding, considerable spread of virus occurred in the 1950–53 experiments, but there are insufficient results from the 1955–57 tests to assess the area.

Data from the Denbigh sites indicate more aphid movement and virus spread than in the Lleyn peninsula. Mid-Wales sites had a fairly high index of aphid movement as assessed by angle of colonization; from previous results most virus spread occurs in late July, which is after the early varieties have been harvested. Were maincrop varieties commonly grown instead of earlies, virus spread might prove too great for high-grade seed production.

The most oustanding feature of the 1955–57 experiments is the relatively low correlation between aphid movement and virus spread, compared with the 1950–53 results. Several factors doubtless contribute, but perhaps the most important is the different proportion of infected plants initially present in the various crops. In the 1950–53 experiments, a constant number of infected tubers was introduced into uniform stocks of variety Majestic, which were virtually free from other infection. This contrasts with the considerable range of leaf roll initially present in the 1955–57 stocks, and the number of different potato varieties involved. Some of the crops studied contained no virus infection detectable by the sampling methods used. The amount of infection introduced into such stocks from external sources in all but the worst seed areas also proved too small to be detected by the sample counts. Under these conditions, the assessment of areas by their indices of aphid movement, giving a measure of the potential virus spread, provides a more sensitive comparison than does measured virus spread.

SUMMARY

Methods developed in 1950–53 experiments for assessing aphid movement in relation to virus spread were applied on a wider scale in 1955–57 in the seed potato growing areas of England and Wales. There was a significant positive correlation between the angle of colonization of *Myzus persicae* and the spread of leaf roll in the potato crops, although the regression of leaf roll spread on angle of colonization differed considerably from year to year. But only 12 per cent

of the crops with angle of colonization less than 55° showed virus breakdown (i.e., more than 5-fold increase in leaf roll), compared with 31 per cent of those with 55–59°, and 47 per cent of those with greater than 59°.

The relative suitability of the different seed areas is discussed in the light of measured aphid movement and virus spread.

Thanks are due to Dr. L. Broadbent, Mr. G. D. Heathcote and Mrs. N. McDermott for their help in this experiment, and to all members of the National Agricultural Advisory Service whose co-operation made the experiment possible, and in particular to Messrs. W. H. Barker, A. Beaumont, W. J. Bevan, W. Campbell, E. S. Carter, H. E. Croxall, D. L. G. Davies, T. G. Davies, C. A. T. Edwards, D. W. Empson, J. H. Fidler, W. H. Golightly, D. C. Gwynne, R. G. Haines, J. W. Hibler, T. D. Holmes, D. W. Ironside, D. M. Jones, D. R. Humphrey Jones, J. Bradley Jones, I. Kinloch, S. C. Melville, H. G. Morgan, H. C. F. Newton, Miss T. Norman, Messrs. L. Ogilvie, J. P. Rogerson, W. R. Rosser, L. N. Staniland, R. E. Taylor, J. D. Thomas, H. W. Thompson, J. H. White, P. Wiggell, J. J. W. Williams and H. C. Woodville.

REFERENCES

B.M.S. (1948). The Measurement of Potato Blight. *Trans. Brit. Mycol. Soc.*, **31**, 140–1.

BROADBENT, L., DONCASTER, J. P., HULL, R. and WATSON, MARION A. (1948). Equipment Used in Trapping and Identifying Alate Aphids. *Proc. R. Ent. Soc., Lond.*, (A), **23**, 57–8.

HOLLINGS, M. (1955). Aphid Movement and Virus Spread in Seed Potato Areas of England and Wales, 1950–53. *Plant Pathology*, **4**, 73–82.

HOLLINGS, M. (1958). The Measurement of Aphid Activity in Relation to Spread of Potato Viruses. *Proc. third Conf. Potato Virus Diseases, Lisse-Wageningen 1957*, 85–90.

GREEN MANURING AND CEREAL ROOT EELWORM

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LINFORD (1937) showed that, when pineapples were grown in pots containing infected soil, the incorporation of chopped green pineapple tops was effective in protecting the plants from root knot eelworm. He considered that the protective effect was due to the stimulation of predacious fungi that attack eelworms. These fungi are known to occur in soil in large numbers (Linford and Oliveira, 1938; Duddington, 1954), where they probably subsist partly as saprophytes and partly as predators on the free-living soil nematodes. Linford showed that the addition of green plant material to the soil resulted in an increase in the population of free-living soil nematodes, and that this was followed by an increase in the activity of the naturally-occurring predacious fungi; after which the numbers of both free-living nematodes and infective larvae of the root knot eelworm were greatly reduced. Unfortunately, Linford's work was not followed up.

In the spring of 1954, experiments were started at the Wolverhampton headquarters of the N.A.A.S., West Midland Region, with a view to finding out whether Linford's results could be repeated for cereal root eelworm. The initial experiments were set out in twelve small plots, each 2 feet square, separated by grass borders 3 feet wide. In each plot two parallel furrows were drawn with a hoe and filled with soil from another source that was known to be infested with *Heterodera major* O. Schmidt. This soil, of which 3 lb was added to each row,

contained 0·3 viable cysts per gramme. Six of the twelve plots, taken at random, were green manured with 1½ lb of chopped cabbage leaves per plot, the other six being left, untreated, as controls. On April 7, spring oats, var. Eagle, were sown along the rows of infested soil on all plots, which were given a liberal dressing of NPK fertilizer.

Germination was good on all plots. On May 28, all the seedlings were lifted from one of the two rows on each plot, care being taken to avoid damage to the roots. Out of the plants lifted from each plot ten were taken at random and their roots were stained with acid fuchsin in lactophenol after gently washing away as much as possible of the adhering soil. After staining, the root system of each seedling was spread out in lactophenol and pressed between glass plates, and the larval stages of *H. major* that had invaded the roots were counted.

On the untreated plots, the mean number of *H. major* individuals per root system was 31·8, compared with 12·3 for the treated plots. The mean difference of 19·5 $\pm$ 9·98 just failed to reach significance at the 5 per cent level.

When the seedlings were lifted, ten small samples of soil were taken from along the row in each plot. These were examined for activity of predacious fungi. One gramme of soil from each sample was placed in the bottom of a sterile Petri dish, and sterile rabbit dung agar (Duddington, 1955), cooled to near solidifying point, was poured into the plate, which was gently rocked to distribute the soil. The plates were then incubated at room temperature for two weeks, after which they were examined. Two nematode-trapping fungi were found to be present: *Arthrobotrys oligospora* Fres. and *Dactylaria thaumasia* Dreschler, both capturing nematodes by adhesive networks. The activity of these fungi was assessed, marks being given on an arbitrary scale as follows:

0: No predacious fungi observed. 1: Very slight activity.
2: Slight activity. 3: Moderate activity.
4: Great activity. 5: Very great activity.

For the untreated plots the mean mark awarded was 1·1 as against 1·7 for the mean of the treated plots. The mean difference of 0·6 $\pm$ 0·396 does not reach the 5 per cent level of significance.

The plants left in the plots were allowed to grow to maturity and kept under observation. The plants in the control plots soon began to show typical symptoms of eelworm damage, as indicated by height and coloration, whereas in the treated plots the plants were, in the main, healthy. On June 16 and again on July 2 plant-height measurements were made, ten plants being taken at random from each plot.

The mean heights of the plants in the treated plots were 59·5 $\pm$ 3·3 cm and 71·3 $\pm$ 3·1 cm for the June and July measurements, respectively. The corresponding means for the control plots were 38·2 $\pm$ 2·2 cm and 48·6 $\pm$ 1·3 cm respectively. The differences between these means are highly significant.

At harvest there was a striking difference in the appearance of the treated and untreated plots; the treated ones having formed good ears while the others produced little. Yield figures were not taken because of the small size of the plots.

The figures for the assessment of the activity of predacious fungi are inconclusive and show considerable overlapping; they are based on the arbitrary assessment of laboratory cultures and, apart from the subjective element that is always present in ranking assessments of this kind, it is not at present known how far, if at all, such figures may be indicative of conditions in the field. The increased activity of 55 per cent, however, should be regarded as a suggestion for future investigation. Further experiments to elucidate this point are in progress.

The plant-height measurements show a significant difference between treated and untreated plots, but this may have been due to the manurial effect of the chopped cabbage.

Although the statistical analyses for larval invasion failed to reach the 5 per cent level of significance, the difference between the means was enough to warrant the repetition of the tests along the same lines.

Consequently, similar plots were set up in the same locality in the spring of 1955. The two parallel furrows were each filled with 6 lb of cereal root eelworm-infested soil from the same known source, with a population level estimated at 0·18 viable cysts/g. As in 1954, six of the plots, taken at random, received $1\frac{1}{2}$ lb of chopped cabbage which was worked into the top six inches of the soil, the other six plots being left untreated. Spring oats (var. Star) were sown on April 22, and NPK was applied at 3–4 cwt/acre. On June 16 cereal root eelworm invasion counts were done on the roots as before, the sample being five plants per plot, taken at random.

The mean number of eelworm larvae per root system for the treated plots was $14{\cdot}4 \pm 0{\cdot}7$ as against a mean count of $23{\cdot}6 \pm 9{\cdot}2$ for the controls. The difference between these means, $9{\cdot}2 \pm 3{\cdot}0$, is significant with a probability of less than 0·02.

SUMMARY

The effect of green manuring in reducing the initial eelworm invasion indicated by experiment in 1954 was confirmed in 1955.

We should like to thank Mr. H. C. F. Newton, Regional Entomologist, N.A.A.S., West Midland Region, for kindly giving us facilities for carrying out the work, and Miss Shirley Ardley, Dr. Sylvia Main and Mr. D. W. Twomey for their assistance. The work was partly financed by a special research grant to one of the authors (C.L.D.) from the Agricultural Research Council, to whom our thanks are also due.

REFERENCES

DUDDINGTON, C. L. (1954). Nematode-destroying Fungi in Agricultural Soils. *Nature, Lond.*, **173**, 500–1.

DUDDINGTON, C. L. (1955). Notes on the Technique of Handling Predacious Fungi. *Trans. Brit. mycol. Soc.*, **38**, 97–103.

LINFORD, M. B. (1937). Stimulated Activity of Natural Enemies of Nematodes. *Science*, **85**, 123–4.

LINFORD, M. B. and OLIVEIRA, J. M. (1938). Potential Agents of Biological Control of Plant Parasitic Nematodes. *Phytopathology*, **28**, 14.

CONTROL OF HALO BLIGHT IN OATS

by D. J. GRIFFITHS *and* W. T. H. PEREGRINE
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THE appearance of halo blight, *Pseudomonas coronafaciens* (Elliot) Stapp, in field plots of oats at the Welsh Plant Breeding Station in 1954 (Griffiths and Peregrine, 1956) prompted various investigations into the most effective methods of control by seed treatment, as well as a search for varietal resistance to the disease. The first part of this paper deals with the results of two field trials conducted in successive seasons (1956 and 1957) involving the use of various treatments on infected seed, and the second part with the varietal reactions.

Partial control has formerly been obtained through treatment of seed with formaldehyde solution (Elliot, 1920; Moore and Moore, 1950), but in view of recent successes with antibiotics in controlling bacterial diseases of crop plants, it was decided to test some of them as a means of controlling halo blight of oats.

1956 TRIAL

The trial in this first year was laid down in a five-replicate randomized block design, each plot consisting of one farm-drill width of Milford S 225 oats, approximately 175 yards long. The seed treatments were:

Soaking in: Streptomycin 50 i.u. per ml, followed by air drying.
Aureomycin 200 p.p.m., followed by air drying.
Formalin, 1 pint in 40 gal water, followed by air drying.
Hot water for four hours at 35°C, followed by ten minutes at 51–52°C; the seed then being rapidly cooled and air dried.

Dusting with: Harvesan, organo-mercury dust, at 1 g per lb.
Agrosan, organo-mercury dust, at 1 g per lb.

The grain used had been harvested from an infected crop grown in the same field the previous season, in which the level of infected plants had been estimated at approximately 4 per cent (Griffiths and Peregrine, 1956). For experimental purposes this level of infection was considered rather low, but a suitable artificial inoculation technique had not yet been evolved; nevertheless, interesting differences in treatment effects were observed.

When the plants were in the single-leaf stage, counts were made to determine treatment effects on seedling establishment, and data were collected on the initial incidence of halo blight in the plots when the plants were in the 4–5 leaf stage, and after panicle exsertion by counting infected heads. The results (Table 1) show that all treatments gave better establishment than the control, and throughout the growing season the antibiotic plots were decidedly superior to all other treatments in general vigour and colour.

The results also indicate clearly that the antibiotic, hot water, and formalin treatments all effectively reduced initial infection, while the antibiotics, especially streptomycin, gave the best control and the best seedling establishment. For panicle infection similar trends in the relative effectiveness of the various treatments were obtained, although less precise differences were expected in a replicated trial of this type, since infection of the flag leaf, sheath and panicle develops as a result of secondary infections brought about by spore spread from loci of infected plants (Peregrine, *in lit.*).

TABLE 1

Effects of Seed Treatment on Naturally Infected Oats, 1956

Treatment	Mean Seedling Establishment	Mean Leaf Infection		Mean Panicle Infection
		Observed	*Transformed Values**	
Streptomycin	569·2	3·2	1·74	9·4
Aureomycin	528·2	10·6	2·61	9·4
Hot water	549·4	16·8	4·01	12·4
Formalin	447·0	19·4	4·13	15·6
Agrosan	455·8	57·6	7·52	26·6
Harvesan	458·0	63·4	7·79	25·0
Control	397·8	107·0	10·08	28·6
Significant difference (P = 0·05) ..	42·11	—	2·14	7·22

* Transformation: $\sqrt{n + 0{\cdot}5}$

1957 TRIALS

The positive results obtained in 1956 prompted further investigations along similar lines in 1957, using artificially inoculated seed, and a modified field experimental layout. The treatments were the same as those used in the previous season, except that the two organo-mercuric dusts were replaced by agrimycin and terramycin, each at a concentration of 200 p.p.m. Inoculation was accomplished by placing the grain in a suspension of a 48-hour old culture of the *Pseudomonas coronafaciens* bacterium under partial vacuum for one hour. Following this, two different procedures were adopted:

1. Incubation of the inoculated seed for 24 hours *after* the treatment.
2. Incubation for 24 hours *before* treatment.

TABLE 2

Effects of Seed Treatments on Artificially Inoculated Oats, 1957

Treatment	Mean Establishment Values per Plot				Mean Number of Diseased Seedlings per Plot			
	Procedure 1		*Procedure 2*		*Procedure 1*		*Procedure 2*	
	No. per Plot	*Percentage*	*No. per Plot*	*Percentage*	*Per cent Infected*	*Transformed Values**	*Per cent Infected*	*Transformed Values**
Streptomycin	233	77·7	161	53·7	0·86	4·83	0·0	0·0
Agrimycin ..	215	71·7	153	51·0	1·83	7·38	0·46	2·41
Aureomycin ..	212	70·7	125	41·6	0·98	5·19	1·80	6·84
Terramycin ..	185	61·7	149	49·6	1·73	7·48	1·07	5·76
Hot water ..	194	64·7	123	41·0	1·04	4·93	1·33	5·36
Formalin ..	165	55·0	129	43·0	1·20	5·92	0·37	1·76
Control ..	144	48·0	163	54·3	4·22	11·44	2·76	9·07
Significant Difference (P = 0·05)	22·8		32·8			2·57		3·32

* Transformation: $\sin^2 \theta$

The results (Table 2) show that incubation of the inoculated seed before treatment resulted in a much inferior plant establishment in all field plots, and also gave a lower halo blight infection amongst established seedlings, as revealed by the respective levels of infection observed in the control plots.

With Procedure 1, except in the formalin treatment, the figures for seedling establishment are again significantly higher than those for the control plots; with streptomycin, aureomycin and agrimycin giving establishment values of over 70 per cent.

Although Procedure 2 gave impaired germination, particularly on the plots treated with hot water and aureomycin, the data revealed significantly inferior seedling braird in comparison with the control plot. However, the antibiotics, especially streptomycin, again proved effective in reducing the proportion of infected seedlings in the plots.

Glasshouse and laboratory tests revealed that poor establishment in the field was due to the high rate of mortality amongst infected seedlings, a large proportion of which died at the first-leaf stage before appearing above ground, a feature also observed and reported by Kingsolver (1944).

It is thus clear that some of the antibiotics, especially streptomycin, offer a relatively cheap and effective means of controlling, and even eliminating, halo blight from seed oats. Furthermore, treatment with antibiotics proved superior to the alternative methods of treatments in respect of subsequent germination in the field, and in seedling vigour. Indeed, it may be stated that the overall improvement in both germination and seedling vigour warrants further investigation into the possible uses of antibiotics in relation to seed harvested in wet seasons.

VARIETAL REACTION TO HALO BLIGHT

The fairly extensive collection of oat varieties maintained at the Station was also tested for reaction to infection. Reports of varietal resistance are few although, as early as 1920, Elliot observed differences in reaction to infection on an unnamed series of varieties at Wisconsin, U.S.A. She stated that certain varieties showed fewer lesions than others at the beginning of the season, but the degree of infection became progressively less marked as the severity of the attack increased and as the season advanced. Essentially similar results were obtained by Aamodt and Platt (1936) who concluded that none of the ninety-seven varieties tested was immune, and there did not appear to be any distinct differences between the reactions of the various species tested. Of the series tested, Lee, a variety of *Avena sativa*; Chinese Hulless, a variety of *A. nuda*; Black Algerian, Culred, and Red Rustproof, varieties of *A. byzantina*, appeared to be the most resistant.

More recently Kingsolver (1944) has reported sources of field resistance. The varieties Anthony, Boone, Marion, Bannock, Gopher, Landhafer and Mutica Ukrainica, together with selections from crosses of these parents, were found to be, in general, wholly susceptible. Derivatives of the cross Victoria × Richland were mostly intermediate in reaction, whilst Bond, Fulghum, Victoria and progenies from the cross D 69 × Bond exhibited a degree of resistance approaching immunity. The agricultural varieties since developed from this latter cross, namely Benton, Cherokee and Clinton have shown resistance to halo blight disease under American conditions (Caldwell, Mulvey and Compton, 1946).

In all, over 200 varieties have been tested at the Welsh Plant Breeding Station for reaction to halo blight, including those previously reported to have given resistant reaction. Seedlings were grown in a glasshouse, at a temperature ranging between 58° and 70°F. At the 3–4 leaf stage the plants were sprayed with a

suspension of the bacterium, and incubated under high humidity conditions for forty-eight hours. Within five days following inoculation symptoms appeared in the form of pale green circular lesions on some of the most highly susceptible varieties, and these were considered sufficiently advanced for critical recording after fourteen days.

The observations on the following five infection classes were designated by the symbols 0 to 5, and typical examples of the reactions obtained are reproduced on Plate III.

Host Reaction	*Symbol and Infection Types*
Immune or highly resistant	0 = Occasional small restricted spots which do not develop into lesions.
Resistant	1 = Few small circular lesions, with slight leaf-tip withering.
Moderately resistant	2 = Restricted lesions numerous; occasional fully-developed lesions, moderate leaf-tip withering.
Moderately susceptible	3 = Few to several fully-developed lesions, or yellowing of leaf.
Susceptible	4 = Fully-developed lesions frequent, often coalescing.
Extreme susceptibility	5 = Yellowing of whole leaf, quickly followed by death of all the leaf tissue.

The cultivated varieties and other forms of *Avena* which gave 0 or 1 type reactions are listed in Table 3.

TABLE 3

Classification of Oat Varieties According to Seedling Reaction

Reaction Category	No. of Varieties	Species and Varieties
0. Highly resistant ..	1	Hexaploid form Cc 4146‡
1. Resistant	10	*A. sativa* vars: †Benton, †Clinton, Cherokee, Lee Coldproof, Le Conte, Novi Sad.br.4, Osijek br.191, Old Welsh Land variety Cc 3802, *A. byzantina* var: Cc 4196 and Forkedeer.
2. Moderately resistant	26	*Hexaploid species* *A. sativa*—10 cultivated varieties *A. byzantina*—11 cultivated varieties including Bond* and Fulghum* *A. sterilis*—2 forms *Tetraploid species* *A. abyssinica*—Cc 4391 *Diploid species* *A. hirtula*—Cc 3678 *A. nudibrevis*—Cc 4427
3, 4, 5. Susceptible ..	186	*Hexaploid species* *A. sativa*—147 cultivated varieties *A. byzantina*—30 varietal forms *A. nuda*—3 varietal forms *A. fatua*—3 forms *Tetraploid species* *A. abyssinica*—Cc 4412 *A. vaviloviana*—Cc 4366 *Diploid species* *A. strigosa*—Sandhafer

* Classed as resistant by Kingsolver (1944).
† Reported as resistant by Caldwell *et al.* (1946).
‡ Cc denotes Welsh Plant Breeding accession number.

In the susceptible class are included all the leading commercially-grown varieties except Clinton, Cherokee, Lee Cold-proof, and Le Conte, which are grown in the U.S.A. Apart from Bambu II, which exhibited a 2-type reaction, none of the European varieties exhibited any positive resistance, although there were indications of variation in degree of susceptibility. Under these particular conditions of testing the variety Bond only exhibited a moderate resistance, while Clinton and Cherokee showed a superior resistance type reaction.

Of all the varieties and *Avena* forms tested, only Cc 4146, an unidentified mildew-resistant form, believed to have arisen from a natural cross between *A. sativa* L. × *A. ludoviciana* Dur., proved to possess a type of resistance which approached immunity. Under higher glasshouse temperatures, however, there was a tendency for a slight lowering of the resistance in this particular genotype to give a 1- to 2-type reaction. Observed segregation for reaction in progenies of crosses involving Cc 4146 and susceptible varieties, has also shown that resistance is conditioned by a single independently-inherited genetic factor (Peregrine, *in lit.*), indicating that a really effective approach towards the control of the disease can be made by breeding as well as by seed treatment.

SUMMARY

The investigations described are concerned with the control of halo blight disease in oats by seed treatment, and with the isolation of varieties or forms resistant to the disease. In the seed-treatment experiments the best results were obtained through the use of antibiotics, especially streptomycin, which gave good control of the disease as well as the most satisfactory seedling establishment and development following the seed treatment.

A study of the reactions of some 200 forms of *Avena* to halo blight revealed no lack of resistant material for breeding purposes, although none of the more widely-grown European varieties exhibited a high degree of resistance. Only Cc 4146, however, an unidentified hexaploid form believed to have arisen from a natural cross between *A. sativa* and *A. ludoviciana*, proved to possess a type of resistance which approached immunity; others, including the two American varieties Clinton and Cherokee, though not immune, showed a fairly high degree of resistance.

We thank Miss Irene D. Rees for assistance in the preparation of this paper, and Mr. Harold Richards for the photograph.

REFERENCES

AAMODT, O. S. and PLATT, A. W. (1936). Varietal Testing for the Reaction of Oats to Diseases, Especially Covered Smut. *Can. J. Res.*, C. **14**, 425–37.

CALDWELL, R., MULVEY, R. R. and COMPTON, L. E. (1946). Benton and Clinton, New Disease Resistant Oats. *Bull. Ind. agric. Exp. Sta., No.* **514**, 10 pp.

ELLIOTT, CHARLOTTE (1920). Halo Blight of Oats. *J. Agric. Res.*, **19**, 139–72.

GRIFFITHS, D. J. and PEREGRINE, W. T. H. (1956). Halo Blight of Oats. *Plant Pathology*, **5**, 95–7.

KINGSOLVER, C. H. (1944). Pathogenicity on *Avena* and Growth Response of *Pseudomonas coronafaciens. Iowa St. Coll. J. Sci.*, **19**, 29–31.

MOORE, W. C. and MOORE, F. JOAN (1950). Cereal Diseases. *Bull. Minist. Agric. Fish., Lond., No.* **129**, pp. 34–5.

A METHOD OF ESTIMATING THE NUMBERS OF CABBAGE ROOT FLY PUPAE IN THE SOIL

by R. D. HUGHES

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THE general level of infestation of a brassica crop by cabbage root fly, *Erioischia brassicae* (Bouché), larvae can be evaluated in terms of crop yield, or by the proportion of wilting and dead plants. This proportion is directly related to the numbers of root fly larvae attacking the plants. However, the response of the plant to the attack depends very largely on the prevailing weather; in warm, wet conditions a plant can survive a greater infestation of larvae than would kill it in a hot dry period. Thus the proportion of wilting and dead plants cannot be used to compare infestations on different soils or at different times. Comparison of two infestations can only be accomplished by direct estimates of the numbers of larvae attacking the crops. A brine flotation method for the separation of the larvae and pupae from the soil has been used to estimate populations (Hughes and Salter, 1959), but the large soil samples necessary to include the main root system of the host plant limits the method in practice to detailed research programmes.

Where data are required from large crop areas, a method developed at Wellesbourne may be of use. This consists of taking small samples of soil at known distances from the plant stem and recovering the fly pupae contained in them. An estimate of the number of pupae occurring around each plant can be calculated from these data. The accuracy of this method largely depends on all the larvae having left the plant to pupate in the surrounding soil.

METHOD

A series of soil samples is taken from each of three groups of randomly selected plants. Each sample is taken with a sharpened steel cylinder two inches in diameter, to a depth of six inches. From one group of plants the samples are taken with the cylinder touching the stem of the plant. In the case of turnips, or other crops with swollen roots, these should be removed from the ground and the sample taken to one side of the centre. With the second group of plants

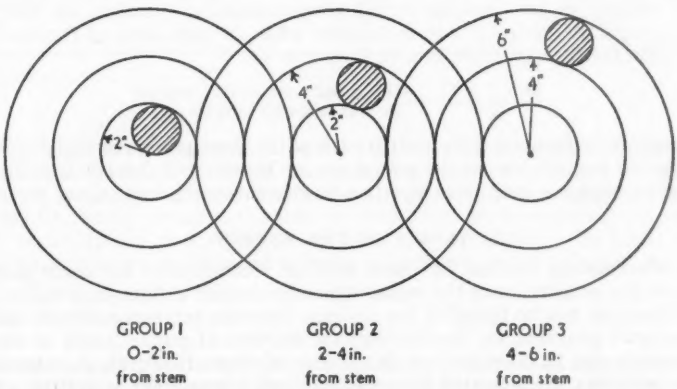

Fig. 1. Areas represented by the soil cores in each of three sampling groups.

the samples are taken with the edge of the cylinder two inches from the plant stem, and on the third group the samples are taken with the sampler four inches from the stem. The location of the soil cores in each of the three series of samples is shown in Fig. 1.

The direction in which the samples lie from the plant stem is immaterial in the case of singly spaced crops (e.g., cabbage) but in the case of unthinned row crops, such as kale, the samples should be taken at right angles to the row. The soil samples from each series of distances must be kept separate, but within a series the samples can be bulked together to reduce the work.

The separation of the pupae from the soil can be achieved by flotation in water, but the treatment of the samples depends on the local variations of the soil. At Wellesbourne, the medium loam soil allows the pupae to be washed from the soil as it passes through a coarse sieve (ten meshes per inch). The pupae are from 6–8 mm long and vary in colour from straw to dark chestnut. They may be identified by the arrangement of tubercules at the posterior end (Miles, 1952).

Three series of ten samples have been used at Wellesbourne in developing the method, and its efficiency has been tested on areas of up to half an acre. While these tests gave satisfactory results the use of the method on larger areas is likely to reduce the accuracy of the population estimate obtained, unless larger numbers of samples are taken. If the large area is divided into ten blocks and one sample at each distance from the plant is taken in each block, the estimate obtained will probably be sufficiently accurate for survey purposes.

CALCULATION OF RESULTS

The numbers of full and empty pupae (and fully grown larvae) in each soil core are recorded separately for the three groups of samples. For singly-planted crops each group of samples represents soil from one of three concentric cylinders surrounding the plant root system, and together the three groups are representative of a cylinder of soil twelve inches in diameter around the plant. However, the two-inch samples represent different proportions of each of three cylinders of soil and correction factors of $\times$ 4 for the 0–2-inch series, $\times$ 12 for the 2–4-inch series, and $\times$ 20 for the 4–6-inch series of samples, are required. The total then gives a good estimate of the number of pupae around the plant.

In the case of unthinned row crops the correction factors are not the same. The average distance between the plants (D inches) must first be estimated. Then, instead of the samples representing concentric cylinders of soil, they represent parallel strips of soil two-inches wide on both sides of the row. The correction factors can, therefore, be shown to be:

$$\frac{D \times 2 \times 2}{\pi} = \frac{4D}{\pi}$$ (π being the surface area of the two-inch sample)

This correction factor is the same for each of the three groups of samples. Thus, the total of the numbers of the pupae per sample in the 0–2-inch, 2–4-inch and 4–6-inch samples is multiplied by $4D/\pi$ to give the number of pupae per plant.

TRIALS OF THE METHOD

A sub-sampling method has been used at Wellesbourne for three years to estimate the proportion of the pupae which lie outside a three-inch radius, and will, therefore, not be found in the six-inch diameter samples normally used in the research programmes. In this way the number of pupae found in the six-inch sample can be corrected for this source of error. However, the number of pupae per plant, as calculated from the two-inch sub-samples, is in itself a good estimate of the total number present (Table 1).

TABLE 1

Comparison of Pupal Population Estimates Obtained by Sub-sampling and Whole Sampling of Root Systems. Summer Cabbage Crop, 1958

	Date	No. Plants	Distance of Sample from Stem *inches*	Average No. Pupae per Sample	Estimated Numbers of Pupae			
					Per Plant		Within Three-inch Radius of Stem	
					Factor	*Total*	*Factor*	*Total*
Two-inch sub-samples	11.8.58	10	0–2	4·0	× 4	16·0	× 4	16·0
		10	2–4	0·5	× 12	6·0	× 5	2·5
		10	4–6	0·1	× 20	2·0	—	—
						24·0		18·5
Six-inch whole plant samples	31.7.58	10	0–3					18·7
	8.8.58	10	0–3					25·9
	14.8.58	10	0–3					20·3

The reliability of the results has been tested on six occasions during 1959, two independent sets of samples being taken in each case. The results are presented in Table 2.

TABLE 2

Repeatability of the Sub-sampling Method

Crop	Number of Pupae per Plant, Calculated from Sub-sample Data		Number of Pupae per Plant, Corrected from Whole Plant Samples
	1st sampling	*2nd sampling*	
Summer Cabbage ..	42·4	54·4	48·5
Cauliflower:			
Treatment 1 ..	64·8	60·4	49·0
Treatment 2 ..	30·2	18·6	not taken
Treatment 3 ..	49·3	59·5	48·6
Treatment 4 ..	12·8	14·6	12·5
Turnip	2·0	1·2	not taken

SUMMARY

A simplified method of estimating the numbers of cabbage root fly pupae in the soil around brassica plants is described. It consists of taking small samples of soil at known distances from the plant stem, and removing the pupae by sieving or flotation in water. On areas up to half an acre, samples from around thirty plants give a good estimate of the pupal population. On larger areas more samples would be required to give estimates of comparable accuracy.

REFERENCES

HUGHES, R. D. and SALTER, D. D. (1959). Natural Mortality of *Erioischia brassicae* (Bouché), During the Immature Stages of the First Generation. *J. Anim. Ecol.* (in the press).

MILES, MARY (1952). Studies of British Anthomyiid Flies, III. *Bull. Ent. Res.*, **43**, 83–90.

THE PERITHECIAL STAGE OF *SPHAEROTHECA HUMULI* ON STRAWBERRY

by MD. ABDUR RASHID KHAN*

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THE perithecial stage of *Sphaerotheca humuli* (DC.) Burr. on strawberries was described and figured by Salmon (1900 a, b) from specimens of infected strawberry petioles sent from the U.S.A. He had not seen this on English strawberries, and there appears to be no other reference to the occurrence of the perfect stage of *S. humuli* on strawberry plants in England.

In May 1959, Royal Sovereign strawberries growing in an unheated glasshouse at Long Ashton, Bristol, showed a heavy infection of the conidial stage of *S. humuli* on leaves, petioles, peduncles and fruits. In late May and June these plants produced a large number of stolons on which patches of conidial infection developed, spreading later to the daughter plants formed on the stolons.

In the last week of June the colour of the felt of mildew on the peduncles bearing the fruit trusses changed from white to yellowish brown, and the surface was seen to be dotted with groups of perithecia. In early July perithecia similarly developed in the mycelium on the pedicels of individual fruits, on sepals attached to withered fruits, and on the mildewed stolons. The perithecia on the stolons occurred most commonly on the underside and in the region of the nodes, rarely on the upper surface of internodes. No perithecia were found on leaves, petioles, petals, fruits or crowns.

The perithecia were gregarious, at first hyaline, then yellowish, becoming dark-brown to black when mature. They were almost spherical, without ostioles, and bore long, unbranched, flexuous appendages (Plate I, 1). Each perithecium contained a single, elliptical, eight-spored ascus showing a conspicuous thin-walled apical zone (Plate I, 2).

The measurements made from this material (counts of fifty were): diameter of perithecium 88–109μ (mean 92μ); ascus 50–99 $\times$ 49–69μ (mean 71 $\times$ 60μ); ascospores 18–25 $\times$ 11–16μ (mean 19 $\times$ 14μ). These measurements agree with those given in Salmon (1900 b) and the appearance of the perithecia, asci and ascospores tallies with the illustration in Salmon (1900a).

I thank Mr. R. W. Marsh for his help with this work which was done at Long Ashton Research Station, and Dr. A. T. K. Corke and Mr. H. R. Mapother for the photographs.

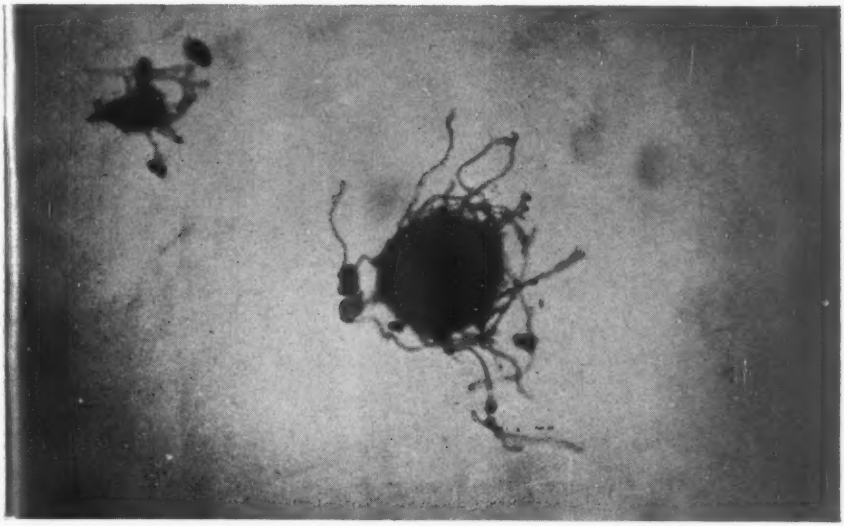
REFERENCES

SALMON, E. S. (1900a). The Strawberry Mildew (*Sphaerotheca humuli* (DC.) Burr.). *J. R. hort. Soc.*, **25**, 132–8.

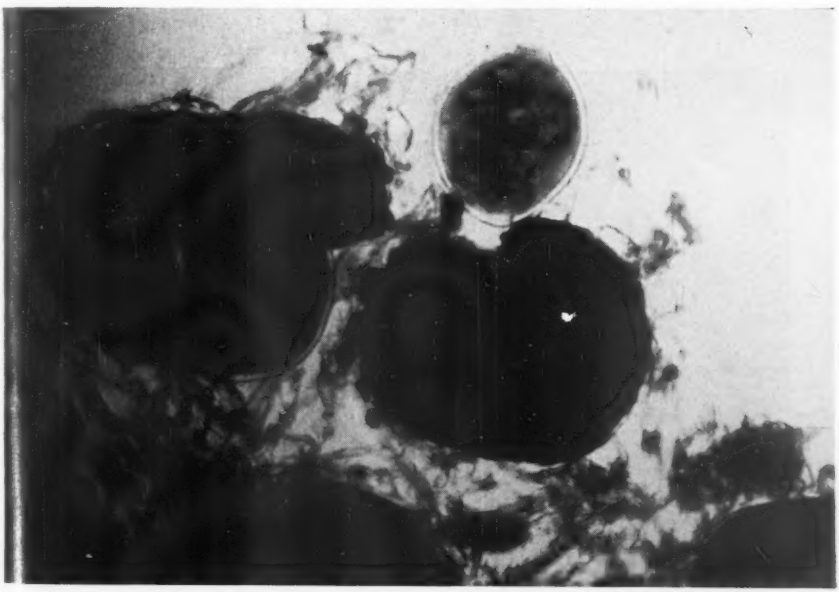
SALMON, E. S. (1900b). A Monograph of the Erysiphaceae. *Mem. Torrey bot. Cl.*, **9**, 292 pp.

* Now at Agricultural Research Station, Tejgaon, Dacca 5, East Pakistan.

PERITHECIA OF *SPHAEROTHECA HUMULI* ON STRAWBERRY



1. Typical perithecium of *Sphaerotheca humuli* on strawberry showing the long, unbranched, flexuous appendages. (× 200)



Photos: Long Ashton Research Station

2. Perithecia of *S. humuli* on strawberry showing a free ascus containing eight ascospores. The thin-walled apex of the ascus is clearly visible. (× 400)

PLATE I

SWEDE MIDGE ON SAVOYS (see p. 25–8)

1. Early symptoms of damage, showing distortion caused by larvae feeding on petiole of young leaf.

2. Multiple heading resulting from the early damage.

HALO BLIGHT IN OATS (see p. 10–4)

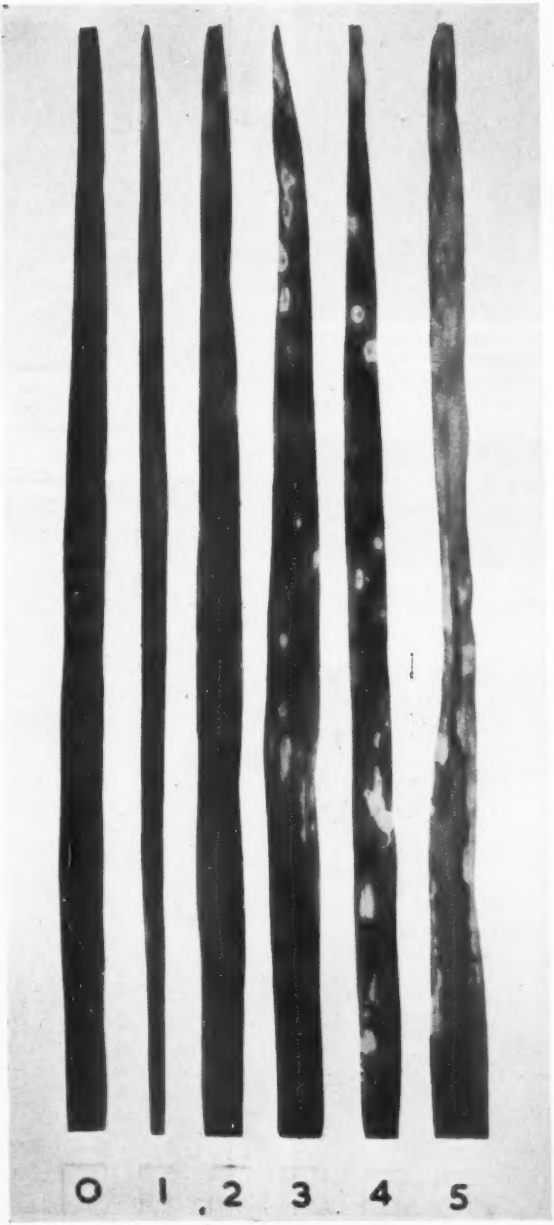
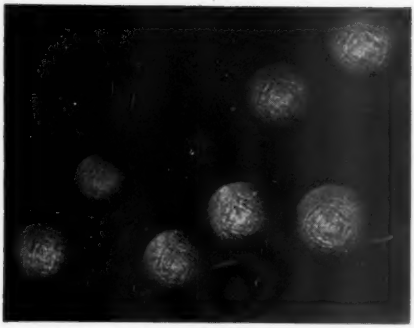


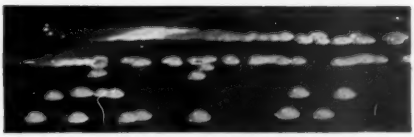
Photo: Welsh Plant Breeding Station

Types of infection. For designations see p. 13.

PLATE III



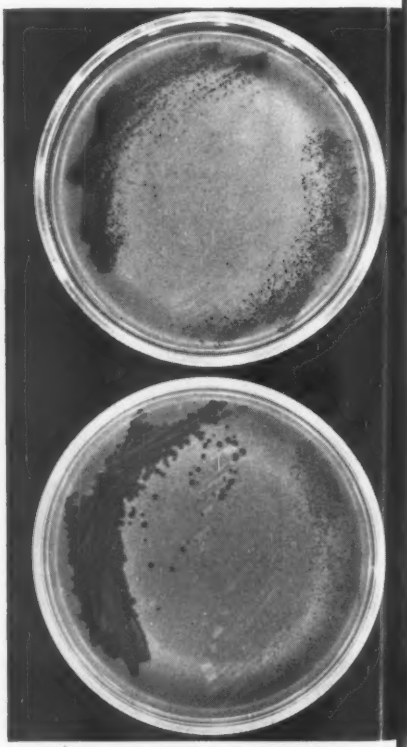
1. Typical colonies of *Erwinia amylovora* after two days at 30°C on yeastrel-peptone agar, showing square pattern. (× 10)



2. Domed colonies of *E. amylovora* after two days at 25°C on sucrose agar. (× 1)

3. Pear fruitlets four days after inoculation with *E. amylovora* showing lesions and bacterial ooze. (× 1)

4. Phages with large and small plaque forms on a culture of typical *E. amylovora* after twenty-four hours at 25°C. (× ½)



Photos: East Malling Research Station

5. The same phages on two different *Erwinia*-like organisms. Note smaller plaque size and absence of clear halos round plaques. (× ½)

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LABORATORY DIAGNOSIS OF FIRE BLIGHT AND BACTERIAL BLOSSOM BLIGHT OF PEAR

by EVE BILLING
National Agricultural Advisory Service, Wye, Kent
and
J. E. CROSSE *and* CONSTANCE M. E. GARRETT
East Malling Research Station, Kent

FIRE blight has only recently appeared in Britain (Crosse, Bennett and Garrett, 1958), and many workers in this and other European countries will be unfamiliar with the disease. Detailed descriptions of the causal organism, *Erwinia amylovora* (Burr.) Winslow *et al.*, can be found in the literature (Stewart, 1913; Ark, 1937; Dowson, 1939), but these are sometimes contradictory and with one exception (Reid, 1930) give little guidance on characters most useful for diagnostic purposes.

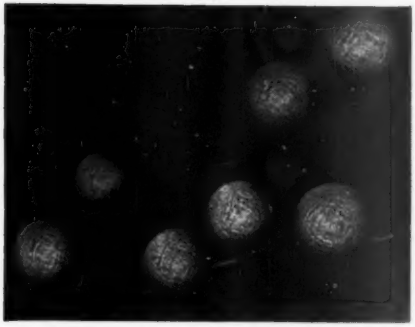
As an attempt is being made to eradicate the disease from this country (Lelliott, 1959), rapid laboratory identification of *E. amylovora* is essential, particularly in cases where field symptoms are atypical. In our experience it is also the only means by which hold-over cankers, present on trees during the winter and spring, can be distinguished with certainty from cankers caused by other agencies. Another important aspect of laboratory identification is the need to distinguish quickly between the early, blossom stages of fire blight, and bacterial blossom blight of pear caused by *Pseudomonas syringae* Van Hall. This problem was encountered in the spring and early summer of 1959, when an epidemic of blossom blight occurred at a time when every effort was being made to locate new outbreaks of fire blight. The symptoms produced in blossoms by the two diseases are similar, and confusion between them may have been responsible for unconfirmed reports of fire blight originating from Europe in the last fifty years (Pethybridge, Moore and Smith, 1934). Descriptions of fire blight and blossom blight are given by Crosse, Bennett and Garrett (1959) and Wormald (1946) respectively.

The following is an account of the methods developed in these laboratories during the last two seasons to identify *E. amylovora* and *Ps. syringae*. Apart from these two pathogens, a variety of saprophytic bacteria may be isolated from pear and other plant material where fire blight is suspected. While these do not form a homogeneous group, most possess characters by which they can be readily distinguished from the pathogens.

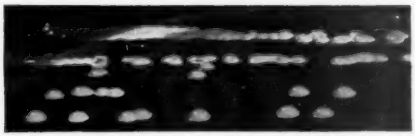
ISOLATION METHODS

During the spring and summer, *E. amylovora* can usually be isolated without difficulty from diseased primary and secondary blossoms, from shoots and from active branch cankers; the leading edge of the infection is most likely to yield pure cultures. Small pieces of diseased tissue, preferably from the cortical layers, where the pathogen tends to be confined, are macerated in a drop of sterile water on a slide. If bacterial ooze is detected the suspension is streaked on to one or both of the media recommended below.

Isolations from hold-over cankers are more likely to be attended by saprophytic organisms. In the winter and spring, hold-over cankers which are dry and brown and show a clear line of demarcation often yield few if any organisms, although

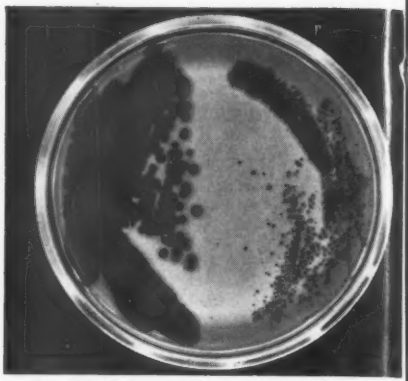


1. Typical colonies of *Erwinia amylovora* after two days at 30°C on yeastrel-peptone agar, showing square pattern. (× 10)

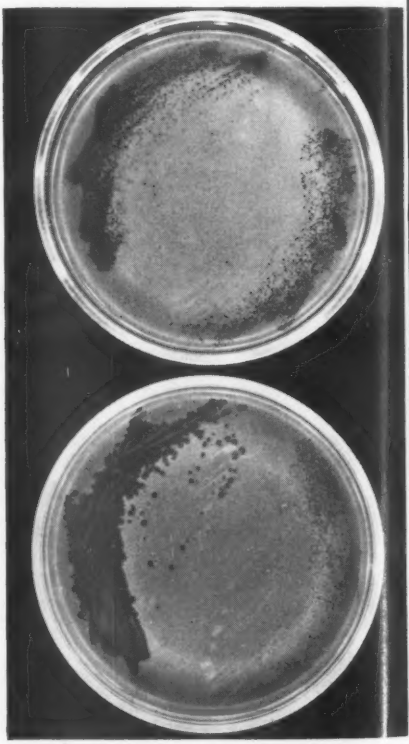


2. Domed colonies of *E. amylovora* after two days at 25°C on sucrose agar. (× 1)

3. Pear fruitlets four days after inoculation with *E. amylovora* showing lesions and bacterial ooze. (× 1)



4. Phages with large and small plaque forms on a culture of typical *E. amylovora* after twenty-four hours at 25°C. (× ½)



Photos: East Malling Research St tion

5. The same phages on two different *Erwinia*-like organisms. Note smaller plaque size and absence of clear halos round plaques. (× ½)

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LABORATORY DIAGNOSIS OF FIRE BLIGHT AND BACTERIAL BLOSSOM BLIGHT OF PEAR

by EVE BILLING
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FIRE blight has only recently appeared in Britain (Crosse, Bennett and Garrett, 1958), and many workers in this and other European countries will be unfamiliar with the disease. Detailed descriptions of the causal organism, *Erwinia amylovora* (Burr.) Winslow *et al.*, can be found in the literature (Stewart, 1913; Ark, 1937; Dowson, 1939), but these are sometimes contradictory and with one exception (Reid, 1930) give little guidance on characters most useful for diagnostic purposes.

As an attempt is being made to eradicate the disease from this country (Lelliott, 1959), rapid laboratory identification of *E. amylovora* is essential, particularly in cases where field symptoms are atypical. In our experience it is also the only means by which hold-over cankers, present on trees during the winter and spring, can be distinguished with certainty from cankers caused by other agencies. Another important aspect of laboratory identification is the need to distinguish quickly between the early, blossom stages of fire blight, and bacterial blossom blight of pear caused by *Pseudomonas syringae* Van Hall. This problem was encountered in the spring and early summer of 1959, when an epidemic of blossom blight occurred at a time when every effort was being made to locate new outbreaks of fire blight. The symptoms produced in blossoms by the two diseases are similar, and confusion between them may have been responsible for unconfirmed reports of fire blight originating from Europe in the last fifty years (Pethybridge, Moore and Smith, 1934). Descriptions of fire blight and blossom blight are given by Crosse, Bennett and Garrett (1959) and Wormald (1946) respectively.

The following is an account of the methods developed in these laboratories during the last two seasons to identify *E. amylovora* and *Ps. syringae*. Apart from these two pathogens, a variety of saprophytic bacteria may be isolated from pear and other plant material where fire blight is suspected. While these do not form a homogeneous group, most possess characters by which they can be readily distinguished from the pathogens.

ISOLATION METHODS

During the spring and summer, *E. amylovora* can usually be isolated without difficulty from diseased primary and secondary blossoms, from shoots and from active branch cankers; the leading edge of the infection is most likely to yield pure cultures. Small pieces of diseased tissue, preferably from the cortical layers, where the pathogen tends to be confined, are macerated in a drop of sterile water on a slide. If bacterial ooze is detected the suspension is streaked on to one or both of the media recommended below.

Isolations from hold-over cankers are more likely to be attended by saprophytic organisms. In the winter and spring, hold-over cankers which are dry and brown and show a clear line of demarcation often yield few if any organisms, although

isolated pockets of infection may sometimes be located. If the diseased tissues are moist-brown, bacteria will readily be detected on microscopic examination but, because of the abundance of saprophytes, it may be necessary to attempt isolations from more than one part of the canker before colonies of *E. amylovora* are obtained. Shortly before the spring blossom period, if conditions are favourable, some hold-over cankers become active again and the infection spreads into the adjacent healthy bark, causing a foxy-red discoloration of the cortical tissues. From such newly-invaded regions the pathogen can usually be isolated without difficulty, and often in pure culture.

When branch samples are taken for diagnosis, therefore, it is most important to ensure that the cankered area and adjacent healthy tissues are included. Branches and shoots above the canker may have died from starvation and attempts to isolate from these will give false negative results.

Ps. syringae infection is usually confined to primary blossoms in the spring. Occasionally it invades spurs and branches, causing small cankers. The latter are analagous to the newly-formed active cankers of fire blight, and isolation from them is not normally very difficult.

MEDIA

YEASTREL-PEPTONE AGAR

	per cent
Yeastrel	0·3
Peptone	0·5
Agar	1·5

pH 7·2

BASAL MEDIUM FOR SUGAR TESTS

$NH_4H_2PO_4$	0·1
KCl	0·02
$MgSO_4$	0·02
Nicotinic acid	0·01
Agar	1·5

pH 6·6–6·8

Sugar solutions are sterilized by filtration and added separately to give a final concentration of 1·0 per cent

PHAGE MEDIUM

Crosse and Hingorani, 1958 (modified)

	per cent
Difco Yeast Extract	0·3
Peptone	0·5
Glycerol	2·0
Agar	1·0

pH 7·2

SUCROSE AGAR

Nutrient agar	95·0
Sucrose	5·0

NITRATE AGAR

Yeastrel	0·3
Peptone	0·5
Potassium nitrate	0·1
Agar	0·3

pH 7·0

Two media have been used on which typical *E. amylovora*, and *Ps. syringae*, can normally be recognized by their surface colony form:

Yeastrel-peptone agar (*20 ml per plate*). After two days incubation at 30°C, colonies of *E. amylovora* are about 1·0–1·3 mm in diameter, circular with an entire edge, white or grey-cream, slightly iridescent and with characteristic line markings forming a square pattern when viewed with a lens by oblique transmitted light (Plate IV, 1). These markings are not specific for *E. amylovora*; a similar pattern has been observed with some strains of *Pectobacterium carotovorum*, but this latter organism would not normally be found in the material in question.

Incubation at 30°C is essential for demonstrating this colony form. At 25°C, colonies on this medium tend to be featureless and difficult to distinguish from other bacteria.

Sometimes on initial plating, two types of colony will be observed, both of *E. amylovora*. Those of the second type are normally greyer than the colony described above, and either show only faint markings or none at all and iridescence is very slight or absent. These atypical colonies may, occasionally, be the only

ones observed on plating; in practice, however, when different specimens from the same source are plated, typical forms are nearly always found in one or more of them. If, as rarely happens, only atypical colonies are present and they cannot readily be distinguished from colonies of saprophytic bacteria, other tests will soon establish their identity.

Ps. syringae strains normally form a greyer colony with an irregular mottled surface pattern; the size is similar. No pigment is produced, but in practice this has not proved a major disadvantage.

As far as saprophytic bacteria are concerned, it is difficult to generalize as a variety of colony forms may be found. In the case of *Erwinia*-like organisms (for this purpose defined as peritrichous gram negative rods producing acid but no gas in salicin media), the one most commonly found has shown a compact, mainly featureless colony which is not unlike an atypical *E. amylovora* except that a central bright spot is often apparent.

Sucrose agar (*20 ml per plate*). After two days incubation *E. amylovora* forms large domed mucoid colonies, 3–4 mm in diameter, cream-coloured and uniform in structure (Plate IV, 2).

Atypical forms vary in appearance on this medium, but in general they show less tendency to form mucoid colonies; some which are non-mucoid at first later produce a watery, white growth.

Colonies of *Ps. syringae* are only slightly mucoid and have a definite mottled surface.

Saprophytic bacteria do not give well-defined mucoid colonies on this medium, though some produce a thin, watery mucoid growth. Many are non-mucoid.

PATHOGENICITY TESTS

In confirmatory pathogenicity tests for *E. amylovora* pear fruits are most satisfactory. They are in best condition from shortly after petal fall until about the end of June, but can still be used until 2–3 weeks before maturity. Immature fruits, collected before the end of July and kept in a refrigerator at 4°C, have been used successfully until the following January. During this period they tend to mature gradually and to be less suitable for pathogenicity tests, although if pear slices are inoculated a good reaction will be obtained over a longer period.

For the test the pear must be kept in a moist atmosphere. Plastic boxes or jam pots containing about 5 ml of water are suitable for the purpose or, when very small fruits or slices are used, they may be placed on damp filter paper in petri dishes and the whole enclosed in a polythene bag to prevent evaporation. The whole pears are inoculated by stabbing some culture through the skin; the slices, by stabbing the cut surface. With *E. amylovora* the production of ooze after 2–4 days is the most characteristic feature (Plate IV ,3). In young fruits and on slices, the ooze will appear as milky beads all over the surface; these eventually turn amber. Young fruits will be completely rotted in 5–6 days, but with older fruits the lesion tends to be localized, the final size of the lesion varying inversely with fruit maturity. In mature, whole fruits, ooze may only be apparent at or around the site of inoculation.

Cut shoots, stood in water and kept under bell-jars, can also be used for pathogenicity tests. Lesions and ooze appear after 2–6 days. Lesions eventually turn black and may extend 10 cm or more along the axis of the shoot. Shoots must be actively growing and in a succulent condition, and preferably of the variety Laxton's Superb. Even so, results may be inconsistent and shoots are not recommended as test material, except perhaps early in the season before fruits are available.

Ps. syringae will produce only a local, dry, black lesion 2–5 mm in diameter on fruits. There will be no ooze. The lesion may be observed as early as 24 hours with some strains, but with others it may take 6–7 days to appear.

PHAGE SENSITIVITY TESTS

Several phages active against either *E. amylovora* or *Ps. syringae* have been obtained, using the method described by Crosse and Hingorani (1958) for the isolation of *Pseudomonas mors-prunorum* phages.

For phage tests, 1 ml of a 24-hour culture in glycerol broth or a suspension from an agar slope is mixed into 12–15 ml of melted, cooled phage medium (p. 20) and poured into a plate. When the medium has set, a loopful of phage suspension is streaked over the surface, in order to obtain isolated plaques. The plates are incubated for 20–24 hours at 25°C.

There is no cross-infection between the phages of *E. amylovora* and *Ps. syringae*, but none so far isolated has proved completely specific for the organism in question. Hence a positive reaction with one or other of the phages will indicate either *Erwinia amylovora* or a closely related organism, or alternatively a *Pseudomonas* species.

For *E. amylovora* two phages have been used to increase the precision of the test. One of these gives plaques c. 1·0 mm in diameter and the other plaques c. 3·0 mm in diameter (Plate IV, 4). With atypical cultures of *E. amylovora* the reaction may be weak or virtually absent. Saprophytic *Erwinia*-like organisms are sometimes sensitive to one or both of these phages, but plaque size is smaller (Plate IV, 5), and with experience there is seldom difficulty in recognizing the true *E. amylovora* reaction.

The position with regard to *Ps. syringae* is more complex because of the occurrence of different phage types, but in practice most of the isolates producing lesions on pear have proved sensitive to one or other of the available phages. The host range of these phages is incompletely known and it may well be that various saprophytes are also sensitive. Experience indicates, however, that if an organism isolated from diseased pear material is phage sensitive and forms colonies of the types described, then it is most probably *Ps. syringae*.

The phages used for diagnostic purposes have been deposited in the National Collection of Plant Pathogenic Bacteria, Plant Pathology Laboratory, Harpenden, Herts.

BIOCHEMICAL TESTS

Acid production from sucrose and salicin, and reduction of nitrates to nitrites, have been found to be the most useful tests for distinguishing the pathogens from saprophytic bacteria. Care is needed in the choice of medium, and of tubes or bottles for the sugar tests.

Neither *E. amylovora* nor *Ps. syringae* produces large amounts of acid on sugar media. If the initial pH of the medium is relatively high and bromocresol purple used as the indicator, barely enough acid may be produced by the organism to lower the pH sufficiently to give a definite yellow colour. Using agar slopes at pH 7·2 in hard glass tubes there was no particular problem, but with ½ oz McCartney bottles the colour change was often poor. It was found that the difficulty could be overcome by adjusting the initial pH of the medium to 6·6 – 6·8.

No extensive comparative tests have been made with broth and agar bases but it seems that, in general, growth and acid production is quicker on an agar slope than in liquid media, and less inoculum is needed.

Starr and Mandel (1950) reported that *E. amylovora* required nicotinic acid for growth. In our experience, growth and acid production occurred in the synthetic medium without the addition of this vitamin, but as it gave much better growth, the inclusion of 0·01 per cent nicotinic acid is recommended in the basal medium for sugar tests.

Acid production from sucrose. Both *E. amylovora* and *Ps. syringae* will produce an acid reaction in one to two days at 25°C. The majority of saprophytic bacteria found in pear and other material examined were unable to grow on the medium and produce acid.

Acid production from salicin. E. amylovora grows slowly on this medium, and an acid reaction will be observed only after three to fourteen days at 25°C. *Erwinia*-like organisms encountered grew well and produced an acid reaction in one to two days. *Ps. syringae* is unable to grow or produce acid on this medium.

Reduction of nitrate to nitrite. Neither *E. amylovora* nor *Ps. syringae* produce a positive reaction in two days at 25°C, but most of the saprophytic *Erwinia*-like organisms did so. Some workers have reported that *Ps. syringae* may give a weak positive reaction, but we have not observed this after two or three days in the medium described here.

RECOMMENDED PROCEDURE

1. Select suitable material from the specimen and macerate in a small drop of sterile water. Look for bacterial ooze.
2. Streak a loopful of the suspension on to yeastrel-peptone agar or sucrose agar. Incubate at 30°C (yeastrel-peptone agar) or 25°C (sucrose agar) for two days, and examine for typical colonies.
3. If typical colonies are evident, re-streak from a well-isolated colony to obtain a pure culture.
4. When a pure culture has been obtained, inoculate the following:
   Suitable pear material for pathogenicity test.
   Glycerol broth for phage sensitivity test.
   Sucrose agar slope.
   Salicin agar slope.
   Nitrate medium.
5. If no typical colonies are observed, re-streak one or more isolated colonies according to the number of different types observed and proceed as for typical colonies.
6. When the primary culture is very mixed, inoculate suitable pear material from the thickest part of the bacterial growth. If *E. amylovora* is present in the mixture, it should develop and produce a typical reaction and isolations can then be made from the bacterial ooze.

When experience has been gained in the recognition of colony form and phage plaque morphology, the biochemical tests may be unnecessary and a positive identification can often be obtained in a much shorter period. If the material is plated in the morning, typical colonies may be recognizable by the following afternoon (i.e., after about 30 hours). Both *E. amylovora* and *Ps. syringae* are frequently found in almost pure culture, and an early phage sensitivity test can often be made by using a suspension from the primary plate to prepare a glycerol agar plate. This has sometimes been successfully done even with bacterial ooze from the original material. Caution must be exercised with such accelerated phage sensitivity tests, however, as non-pathogenic bacteria, which may be sensitive to the available phages, are sometimes present in relatively large numbers in plant material. Finally, for the saving of time, inoculations into pear material for pathogenicity tests may be made either from the primary plate, or, where there is sufficient bacterial ooze, from the diseased specimen.

DISCUSSION

Of all the tests for fire blight diagnosis, pathogenicity in pear is probably the most useful. As far as is known, the production of a milky ooze all over the surface of immature fruits is completely specific for *E. amylovora*. Pear inoculation is also of value for detecting *E. amylovora* in mixed cultures. The main difficulty with regard to this test is that suitable pear material is not always available.

Colony form on either yeastrel-peptone or sucrose agar can be a very valuable guide. It is not considered sufficiently reliable as the sole criterion, but it can be a useful supplement to the phage and pathogenicity tests, apart from facilitating the isolation of the specific pathogen. Of over 150 *E. amylovora* isolates, only eleven showed solely an atypical colony form, and for these it was possible to give a positive identification on the basis of other tests. All strains produced ooze in the pathogenicity tests, though some were slow to do so. Only one was completely insensitive to the phage; two gave a very weak reaction. The remainder gave typical though sometimes faint plaques in the phage sensitivity test. All gave typical reactions in the biochemical tests.

A typical phage reaction and typical colony form together may be sufficient for a positive identification of fire blight when suitable pear material is not available, providing the worker is thoroughly familiar with the colony form and plaque morphology.

The three biochemical tests are mainly of value as screening and additional confirmatory tests. When one or more of the other tests cannot be made or does not give clear cut results, or before experience has been gained in recognizing typical colonies and plaques, they will quickly distinguish atypical colony types of *E. amylovora* from saprophytic *Erwinia*-like organisms and *Pseudomonas* species.

With *Ps. syringae*, the colony form is a less reliable guide, but phage sensitivity plus pathogenicity in pear fruits are together probably sufficient for a positive identification. When pathogenicity cannot be demonstrated, some doubt must remain as to the identity of the isolate, even though it is sensitive to available phages. Although all *Ps. syringae* isolated from blossom blight last season (about fifty in all) have been sensitive, these phages have also attacked *Pseudomonas* spp. which have not been pathogenic to pear. Further knowledge regarding the phage types of *Ps. syringae* may overcome this difficulty in the future. The biochemical tests are less useful as non-pathogenic *Pseudomonas* spp. may give similar results.

SUMMARY

On the basis of experience in 1958 and 1959 a recommended procedure is given for the expeditious laboratory diagnosis of fire blight and bacterial blossom blight of pear. The isolation and recognition of the causal organisms with confirmatory pathogenicity, biochemical and phage-sensitivity tests are described in detail.

We are grateful to Miss L. A. E. Baker for valuable technical assistance, and to Mr. E. Yoxall Jones, East Malling, and Mr. J. J. Walker, Wye, for the photographs.

REFERENCES

ARK, P. A. (1937). Variability in the Fire-blight Organism, *Erwinia amylovora*. *Phytopathology*, **27**, 1–28.

CROSSE, J. E., BENNETT, MARGERY and GARRETT, CONSTANCE M. E. (1958). Fire-blight of Pear in England. *Nature, Lond.*, **182**, 1530.

CROSSE, J. E., BENNETT, MARGERY and GARRETT, CONSTANCE M. E. (1959). Fire-blight Disease of Pear. *Rep. E. Malling Res. Sta. for 1958.*, 151–4.

CROSSE, J. E. and HINGORANI, M. K. (1958). A Method for Isolating *Pseudomonas morsprunorum* Phages from the Soil. *Nature, Lond.*, **181**, 60–1.

DOWSON, W. J. (1939). On the Systematic Position and Generic Names of the Gram Negative Bacterial Plant Pathogens. *Zbl. Bakt.*, II, **100**, 177–93.

LELLIOTT, R. A. (1959). Fire Blight of Pears in England. *Agriculture, Lond.*, **65**, 564–8.

PETHYBRIDGE, G. H., MOORE, W. C. and SMITH, A. (1934). Report on Fungus, Bacterial and other Diseases of Crops in England and Wales, 1928–32. *Bull. Minist. Agric., Lond.*, No. 79, 8–10.

REID, W. D. (1930). The Diagnosis of Fire Blight in New Zealand. *N.Z.J. Sci. Tech.*, **12**, 166–72.

STARR, M. P. and MANDEL, M. (1950). The Nutrition of Phytopathogenic Bacteria. IV. Minimal Nutritive Requirements of the Genus *Erwinia*. *J. Bact.*, **60**, 669–72.

STEWART, V. B. (1913). The Fire-blight Disease in Nursery Stock. *Bull. Cornell agric. Exp. Sta.*, No. 329, 317–71.

WORMALD, H. (1946). Pear Blossom Blight. *J. Pomol.*, **22**, 41–5.

CONTROL OF SWEDE MIDGE ON SAVOYS

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SWEDE midge, *Contarinia nasturtii* (Kieff.) attacks a wide range of cruciferous crops. Early symptoms of damage in savoys are the typical crumple-leaf or button-heart condition, an inward bending of the foliage due to larvae feeding on the inside of the petiole. Feeding scars produced on the petiole make it prone to bacterial soft rots and premature death of the leaf. Later damage to the heart of the plant varies. An inferior product is produced during a light attack, and severe infestation may cause blindness or symptoms similar to the multiple heading in swedes. Early and late symptoms of damage are illustrated in Plate II.

Various insecticides have been tested in the control of swede midge. Bovien and Knudsen (1950) successfully used DDT sprays and dusts on seedbeds and field crops of cabbage and cauliflower in Denmark. Hornig (1953), working on swedes in Schleswig Holstein, tested soil applications of several proprietary preparations against emerging adults, and concluded that any insecticide having a long duration of effectiveness was suitable, but the correct time for treatment was difficult to predict. Osborne and Turner (1957) found that 0·1 per cent DDT emulsion was very effective against swede midge on cauliflowers in the East of Scotland. Thomas (1946) found that savoys were more susceptible to swede midge than other types of cabbage in Devon, and reported considerable losses by growers.

Field trials were carried out at Ellbridge Experimental Horticulture Station during 1956, 1957 and 1958 to assess the damage caused by swede midge to savoys and to evaluate control measures.

1956 TRIALS

On a field crop, three insecticide treatments were replicated four times on small plots which contained eighty-five savoy plants of the variety Ormskirk Medium spaced at eighteen-inch intervals. Insecticides were applied immediately

after planting out on July 27, and three further times at weekly intervals. Dieldrin and malathion sprays (0·1 per cent) were applied with a hand-operated knapsack sprayer, each plant receiving one spray burst at a rate approximately

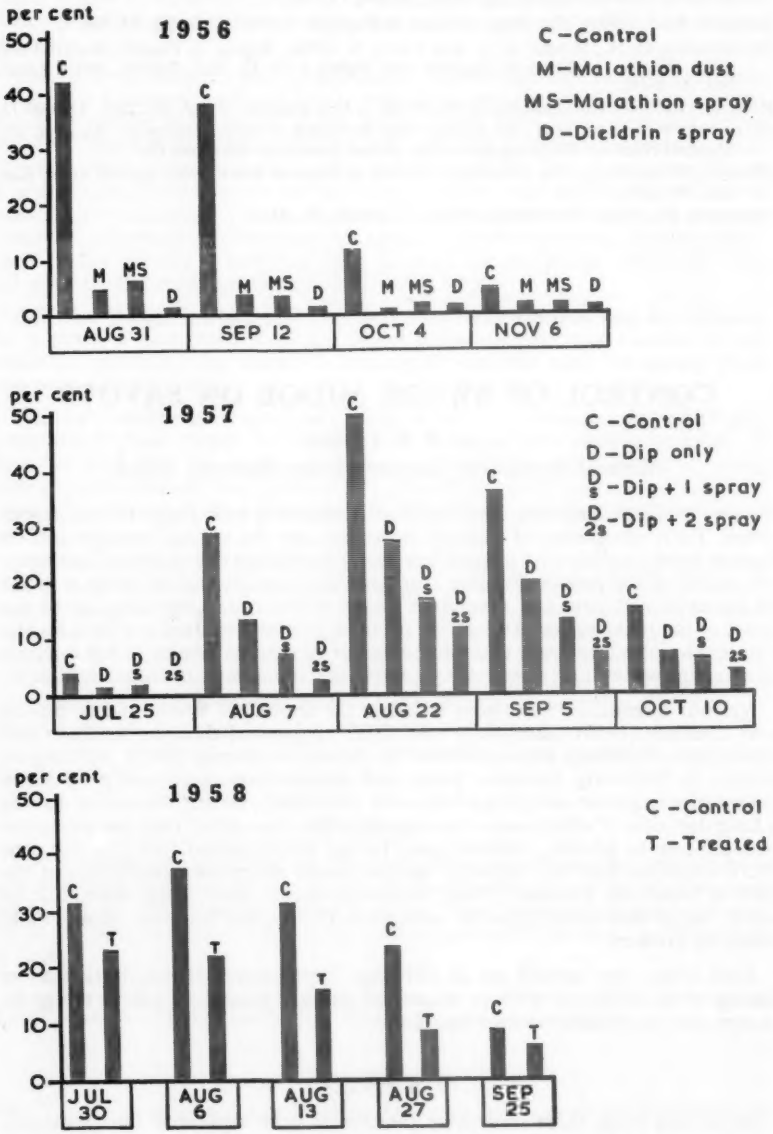

Fig. 1. Percentage of savoys showing symptoms of attack by swede midge in 1956, 1957 and 1958 trials.

equivalent to 200 gal per acre. Malathion dust (4 per cent) was applied with a portable machine adjusted to deliver 150 lb per acre. Control plots received no treatment.

Plots were visually assessed for damage by swede midge, and the results are shown in Fig. 1. At each assessment every plant was examined, and those which showed symptoms of attack were recorded individually on a graph-paper plan of the plots. Columns in the histogram represent a mean count from the four replicates of each treatment. All the treatments applied at weekly intervals greatly reduced swede midge attack; dieldrin was the most effective. Control by insecticide application was most clearly seen during the earlier assessments when symptoms were most easily distinguished. Plants recorded as attacked in early counts often recovered sufficiently to produce a savoy of poor quality, with distinctive symptoms masked by a generally inferior condition.

1957 TRIALS

In view of the successful results obtained with four sprays of dieldrin, it was worth finding out the minimum number of treatments for economic control of swede midge. The treatments consisted of: dipping the complete plant at planting-out time; a dip plus one spray a fortnight later; a dip plus two sprays at fortnightly intervals; control. The dieldrin dip was a 0·05 per cent solution and the spray 0·1 per cent. Control plants had only the root dipped to obviate damage by cabbage root fly, *Erioischia brassicae* (Bouché). The four treatments were replicated eight times in a randomized block. Each plot consisted of 112 plants of the same variety and spacing as in 1956, with eighty central plants assessed for damage.

Damage decreased uniformly with more frequent dieldrin treatments (see Fig. 1), but the yield and marketability data did not reflect this trend. Again, the symptoms of swede midge damage recognizable during earlier growth of the plant became masked in maturity. Plants dipped in dieldrin and planted out in hot sunny weather suffered a slight leaf scorch, which disappeared after fourteen days.

1958 TRIALS

In the final trial, only dieldrin dips were used, since this was considered the most acceptable method of commercial control.

Plants of Ormskirk Late submerged in 0·05 per cent dieldrin and Monoxol (at 8 fl. oz per 100 gal water) were compared with controls, in which the roots only were dipped. There were four replicates of each treatment in plots containing 112 plants, of which seventy were assessed.

Control of swede midge was poor (Fig. 1). The seedbed was not sprayed and, although apparently healthy plants were selected for the field crop, a quarter of the remaining seedlings showed crumple-leaf symptoms, suggesting that many plants contained midge eggs which were not killed by the dieldrin at planting-out time.

SEEDBED TREATMENTS

Seedling savoys were raised near the field crop site, and apparently healthy specimens selected for transplanting. In 1956 and 1957, each group of field treatment replicates was divided so that half received unsprayed and half dieldrin-sprayed seedlings. However, there appeared to be no significant residual effect from the seedbed treatments into the field crop, and the two stages in growth may be considered separately.

Dieldrin, DDT, malathion and nicotine sprays were tested on seedlings in 1956, without any phytotoxicity. A count of crumple-leaf plants in 1957 showed

that they were more than ten times more numerous in the controls than the sprayed plots (7 per cent: 0·6 per cent). The seedlings were not sprayed in 1958, and 25 per cent of the plants were attacked by swede midge.

DISCUSSION

Control of swede midge on savoys was rather difficult to assess accurately because the plant seemed to have great powers of recovery during later stages of growth. Visual assessment of damage was satisfactory in showing that a large proportion of the plants were affected in the seedbed and earlier growth of the field crop, but nearer harvesting it was possible to record with certainty only those plants where the growing point was destroyed. Earlier symptoms of damage were masked as the crop matured; this is clearly shown in Fig. 1 and probably explains why the yield and marketability data did not support the field assessment of damage.

Dieldrin sprays of the seedlings at weekly intervals from the four-leaf stage until they were transplanted ensured a good supply of healthy plants, but there would be practical limitations to spraying large areas of a field crop. Thomas (*in lit.*) and Hornig (1953) have investigated the application of soil insecticides to control emerging adults, but success of the method depended on predicting the correct time for treatment. Such measures would be unlikely to succeed in an intensive market-garden area where brassicas are a prominent crop, and swede midge breed almost continuously from mid June to late September.

SUMMARY

An economic method of complete control of swede midge seems impractical on a slowly maturing crop of low value, such as savoys. Partial chemical control was obtained by using dieldrin as a weekly spray in the seedbed and for completely dipping the plants at planting-out time, thus protecting savoys during the most susceptible stages of growth.

Mr. L. N. Staniland suggested this investigation. Thanks are also due to Mr. D. J. Fuller and Mr. J. Heath at Ellbridge Experimental Horticulture Station; to Mr. M. H. Davies who did much of the field work, and to Mr. H. C. Woodville for the photographs.

REFERENCES

Bovien, P. and Knudsen, P. (1950). Krusesygegalmyggen (*Contarinia nasturtii* Kieff.) dens biologi og bekaempelse. *Tidsskr. Planteavl*, **53**, 235–57.

Hornig, H. (1953). Die Bedeutung der Drehherzmücke (*Contarinia nasturtii*, Kieffer) für den Kohlrübenanbau unter besonderer Berücksichtigung der Verhältnisse in Schleswig-Holstein. *Z. angew. Ent.*, **35**, 271–318.

Osborne, P. and Turner, D. H. (1957). Combating Blindness by Swede Midge. *The Grower, Lond.*, **47**, 552–3.

Thomas, D. C. (1946). A Study of the Distribution of the Swede Midge (*Contarinia nasturtii* Kieffer) in Devon and Symptoms of its Attack on Various Host Plants. *Ann. appl. Biol.*, **33**, 77–81.

OBSERVATIONS ON THE LIFE HISTORY AND CONTROL OF THE VINE WEEVIL ON CYCLAMEN AND FOLIAGE PLANTS

by E. CHRISTINE MASON

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IN March 1953, our attention was drawn to serious losses among cyclamen on a nursery at Turnford, Herts. These plants were being grown mainly for the Christmas flower trade, and it was estimated that at least 1,000 were lost during the late autumn of 1952 through feeding of the larvae of the vine weevil, *Otiorrhynchus sulcatus* (F.).

A comprehensive account of the biology and control of this pest in the U.S.A. was published by Smith (1932), but as there was little information on its biology in Britain, observations were made on the life cycle under glass to determine at which stage control measures could best be applied.

LABORATORY OBSERVATIONS ON BIOLOGY, 1953–54

Between October and December 1953, the period of maturation averaged 63 days for six adult weevils, and varied from 47 to 88 days. During these observations the weevils were caged in a heated glasshouse with a temperature range of 50–70°C; they were fed on cyclamen or dock leaves for a few days then transferred to yew, *Taxus baccata*, L., for the remainder of the period, as this was readily available during the winter months.

Adult weevils are known to reproduce parthenogenetically, and counts were made of the numbers of eggs laid daily by four separate adults of unknown age, during November and December 1953 (Table 1).

TABLE 1

Daily Oviposition Records of O. sulcatus

Weevil	No. Days	No. Eggs	Average per Day
1	16	79	5
2	10	99	10
3	17	293	17
4	3	20	6

These were followed by observations on four adults which had matured in January and February 1954, and again individual daily oviposition figures were noted until early April (Table 2), though oviposition would probably continue for a further period under commercial glasshouse conditions.

From Table 2 it will be seen that the average number of eggs laid in each 24-hour period by one adult was seven; there was a range of 0–28. Smith (1932) found that different host plants considerably affected the number of eggs laid, so that adults confined on yew produced only about half as many eggs as those on fairy primrose, *Primula malacoides*, Franch, which gave the highest oviposition average.

During February and March 1954, sixteen batches, totalling 297 eggs, were kept on moist filter paper in covered petri dishes, at laboratory temperature, 55–65°C. Hatching took place 15–36 days after oviposition, commencing usually on the nineteenth day and extending over a six-day period; 59 per cent hatched.

TABLE 2

Daily Oviposition Records of Four Newly-matured Adults

Weevil	No. Days	No. Eggs	Average per Day
A	100	630	6
B	104	727	7
C	59	495	9
D	87	535	6

Eggs kept dry and left exposed to the atmosphere in the laboratory did not develop and, after about ten days, their shells collapsed. One small batch of eggs was immersed in water and kept at room temperature. After twenty-three days the first egg hatched normally, and an 82 per cent hatch was reached after another nine days. The newly-hatched larvae remained alive for several hours even though submerged.

Attempts to rear first instar larvae were unsuccessful and few observations were made. Second and third instar larvae collected from the nursery were successfully reared on roots of cyclamen, strawberry and dock, *Rumex obtusifolius*, L.

Several pre-pupae kept in bulb fibre in the laboratory became covered with a white mould, identified by Dr. A. H. S. Brown of the Commonwealth Mycological Institute, as *Metarrhizium anisopliae* (Metsch) Sorok. This fungus causes green muscardine disease of insects.

LIFE CYCLE

Observations made in the laboratory and on the nursery suggest that under warm glasshouse conditions the adult weevils, which emerge in numbers over a period of two to three months towards the end of the year, are mature eight to twelve weeks later. Eggs are then laid continuously for at least four months, probably much longer, during the spring and early summer. Larvae from the first-laid eggs are responsible for the severe late-autumn losses among cyclamen, and these will be mature adults by November-December of the same year. Larvae from eggs laid later do not reach the adult stage until early the following year. Under such conditions, though the length of the life cycle of the weevil means that only one generation is completed in a year, there is considerable overlapping and all stages may be found at any one time.

HOST RANGE

Additional host plants to those recorded by Smith (1932) were noted in the course of a visit to heated glasshouses on the nursery in November 1953, when typical vine weevil leaf damage was seen on potted foliage plants. Closer examination showed that plants of *Cissus antarctica*, Vent., were the most severely affected by adults, and that larvae also were feeding on the roots. Leaf damage was noted on the following—*Hedera canariensis*, Willd., *Spathiphyllum* sp., and *Fatshedera Lizei* (Cochet) Guillaum, but no larvae were found at the roots. *Rhoicissus rhomboidea* (E. Mey) Planch growing in close proximity to heavily-infested plants of *C. antarctica* were not affected.

CONTROL ON CYCLAMEN UNDER GLASS

Smith (1932) found that larvae were killed by the addition of lead arsenate to the potting compost at the rate of 1 or 2 oz per bushel. Recent experiments have been carried out to test the effectiveness of DDT, BHC, aldrin, etc. against all stages in the life history of the weevil by, among others, Loosjes (1951) working on cyclamen in Holland, Pritchard (1952) on azaleas and Neiswander (1953) on yew, in America. Results so far have been rather variable and there is still no standard recommendation.

Preliminary observations were made in 1953 on a crop that had been sown in boxes and beds of unsterilized soil in early August 1952. The plants, when first examined in mid March 1953, were in 2-inch pots (72s) and ready for the second move to 3-inch pots (60s). They would normally be re-potted a third time in June into 4½-inch (48s) and 3½-inch (large 60s) pots, the proportion of each depending on the condition of the plants and trade prospects.

The simplest method of control appeared to be the application of an insecticide to kill larvae already in the soil and those which would hatch from eggs laid subsequently. The following materials were mixed with the additional compost required at the second repotting on March 20, 1953: lead arsenate, DDT, BHC, toxaphene, chlordane, dieldrin and aldrin as dusts. Rates of application are given in Table 3. Dieldrin was also applied as a liquid after the final re-potting on June 16.

There were 100 plants per treatment, and two batches of 100 plants were set aside as controls. Each insecticide was mixed with one bushel of unsterilized compost, this quantity being sufficient to re-pot 100 plants from 2-inch to 3-inch pots. The liquid insecticide (3 fl. oz of 15 per cent dieldrin emulsion in 10 gal water) was applied by a watering can, and approximately two gallons of diluted wash were required for the 100 pots.

TABLE 3

Effect of Insecticidal Treatments

Insecticide and Rate of Application (*oz per bushel of compost*)	Plant Losses Noted During:				Minimum Percentage of Plants Damaged by Larvae
	Aug.	*Sept.*	*Oct.*	*Nov.*	
Lead arsenate 2 ..	1	—	—	—	1
DDT 5 per cent dust 6 ..	1	—	—	—	1
BHC 3·5 per cent dust ½ ..	4	2	8	—	14
Toxaphene 2 per cent dust ½ ..	3	2	1	—	6
Chlordane . 5 per cent dust ½ ..	—	1	2	—	3
Dieldrin 0·89 per cent dust ½ ..	—	—	—	1	1
Dieldrin 0·89 per cent dust 4 ..	—	—	—	—	0
Dieldrin 15 per cent emulsion— (See text)	—	1	—	—	1
Aldrin 0·89 per cent dust ½ ..	—	1	3	—	4
Aldrin 0·89 per cent dust 4 ..	—	—	—	—	0
Control I — ..	—	9	5	1	15
Control II — ..	2	1	2	—	5
Total loss per month ..	11	17	21	2	—

After treatment, the numbers of plants damaged (wilting and with larvae at their roots) were noted by the nursery foreman, and all treatments were inspected at monthly intervals. The experiment involved some 1,200 plants during a period when there was a strong market demand for them. It was necessary therefore,

as soon as appreciable losses were noted in any treatment, to dispose of the rest of the plants in that batch. Plants having received treatments which appeared more effective were retained on the nursery, so that observations could be carried through to the end of the year. Thus plants receiving dieldrin dusts (two rates) and aldrin dust (high rate) were finally examined on December 17, 1953. Plant losses during the autumn, and final results, are given in Table 3, and these numbers must be considered minimal for all the less effective treatments.

The results showed that lead arsenate, DDT, aldrin and dieldrin were worth further trial, though the actual numbers of plants lost from some treatments was possibly higher than the figures indicate. No obvious phytotoxic effects were noted following any treatments.

The cheapest of the more promising materials, dieldrin, was used in 1954 for a further trial. A thousand seedlings (autumn sown) were transplanted into 3-inch pots in early February 1954, and a 1½ per cent dieldrin dust was mixed in with the additional soil required, at the rate of 4 oz dust per bushel of compost. At the same time, 1,000 untreated control plants were brought into the same house. By late August 1954, one plant of the treated batch had died because of larval feeding, but no further losses occurred up to the time the plants were sold in mid December. In the control batch over 100 plants were killed by larval feeding in the same period.

This trial demonstrated fairly conclusively that dieldrin dust was giving an excellent control, and had no harmful effect on cyclamen when applied at the rate of 1·70 g active ingredient per bushel of compost.

For the 1954–55 crop, a 1¼ per cent aldrin dust was used at 3 oz per bushel of compost in place of the dieldrin dust, which was not commercially available, and this proved equally effective when mixed in with the seedbed or re-potting compost.

CONTROL ON FOLIAGE PLANTS UNDER GLASS

On the nursery, the only control measures taken against adult weevils on foliage plants had been an occasional DDT spray, but these appeared ineffective and other methods were tested in November 1953. These included a poison bait of crushed apple and bran mixed with lead arsenate, and a 20 per cent wettable DDT powder dusted over the coke breeze on which the pots stood, but damage continued and neither measure appeared effective. Finally, a parathion smoke was used and twelve hours after treatment about 200 dead beetles were collected from the floor and staging of the house; fumigation was repeated seven days later when about another 100 adults were found. No phytotoxic effects were noted. This treatment was repeated early in 1954 and fewer adults were found after each fumigation.

Small, rooted, cuttings of *Cissus antartica* affected by young weevil larvae were watered with BHC (10 per cent *gamma* isomer), ¾ pint in 100 gal water, and observations made one week later showed that there had been a good kill of larvae and that the plants had made fresh root growth.

SUMMARY

Severe damage by vine weevil larvae to cyclamen and foliage plants on a commercial holding led to observations being made on this insect's life history and host range under glass.

Good protection against larval damage to cyclamen was obtained by the addition of 3 oz of a 1¼ per cent aldrin dust (1·06 g actual aldrin) or 4 oz of a 1½ per cent dieldrin dust (1·70 g actual dieldrin) to each bushel of the potting

compost as it was made up, or well mixed in afterwards; this appeared to give protection against larvae for some six to eight months.

Numbers of adults were greatly reduced by parathion smokes and where non-bulbous plants were already infested by larvae, a 0·01 per cent *gamma*-BHC drench (¾ pint of 10 per cent emulsion to 100 gal water) gave a good kill.

I wish to thank Dr. H. C. Gough, at whose suggestion this work was undertaken, for criticism of the paper; and Mr. T. Rochford of Turnford, Herts for his interest and use of facilities on his nursery.

REFERENCES

Loosjes, F. E. (1951). Enige proeven met bestrijdingsmiddelen tegen de larve van de lapsnuittor (= taxuskever), schadelijk aan cyclamenplanten. *Tijdschr. PlZiekt.*, **57**, 38–42.

Neiswander, R. B. (1953). Control of Black Vine Weevil. *J. econ. Ent.*, **46**, 234–7.

Pritchard, A. Earl. (1952). *Brachyrhinus* Weevils. *Calif. Agric.*, **6**, No. 4, 5 and 16.

Smith, Floyd F. (1932). Biology and Control of the Black Vine Weevil. *Tech. Bull. U.S. Dept. Agric.* No. 325.

THE SPRING OVIPOSITION PEAKS OF FRIT FLY AND ASSOCIATED DIPTERA IN YOUNG OATS

by W. F. Jepson *and* T. R. E. Southwood

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In the three years 1957–59 we have sampled the dipterous eggs found around young oat plants (sown about April 24) in a two-acre field at Imperial College Field Station, Sunninghill, Berks. The samples were taken with a Webley grab sampler; four grabs (i.e., one foot of row) were bulked and the eggs separated by the Salt and Hollick washing techniques.

Sampling was continuous from mid May until late June, and in every year the number of ridged, frit-like eggs showed a peak in the latter month (Fig. 1), well after the main peak of frit fly, *Oscinella frit* L., adults. In 1957 we disregarded these late eggs, attributing them to "an accumulation of non-viable eggs" (Jepson and Southwood, 1958), for it was clear that they were not contributing to the population of frit larvae. In 1958 we investigated these late eggs more closely and were able to show that they were those of *Elachiptera cornuta* Fall. (Choropidae, Oscinellinae); these eggs can with some difficulty be distinguished from those of the frit fly (Jepson and Southwood, 1960). The purpose of the present paper is to show the different seasonal distributions of egg laying in the frit fly, as compared with *E. cornuta* and other associated species, and to draw attention to the considerable risk of incorrect assessment of frit fly egg numbers at certain periods.

Frit fly oviposition occurs at Sunninghill from mid May until the second week of June; it is only towards the end of this period that *E. cornuta* is also ovipositing (Fig. 1). The first *E. cornuta* eggs were found in 1958 and 1959 on June 9 and June 3 respectively; they soon became very numerous and frit fly eggs very scarce in the oatfield.

Another small fly, a species of *Hydrellia* (Ephydridae) is also abundant in the oatfield in early June. Riggert (1935) has described its eggs; they can easily be distinguished from those of the frit fly under the high power of the binocular microscope by various features, more especially the rather granular striations of the chorion. In 1959 we kept a record of the eggs of this species; they were found during the period June 1–14 (Fig. 1)

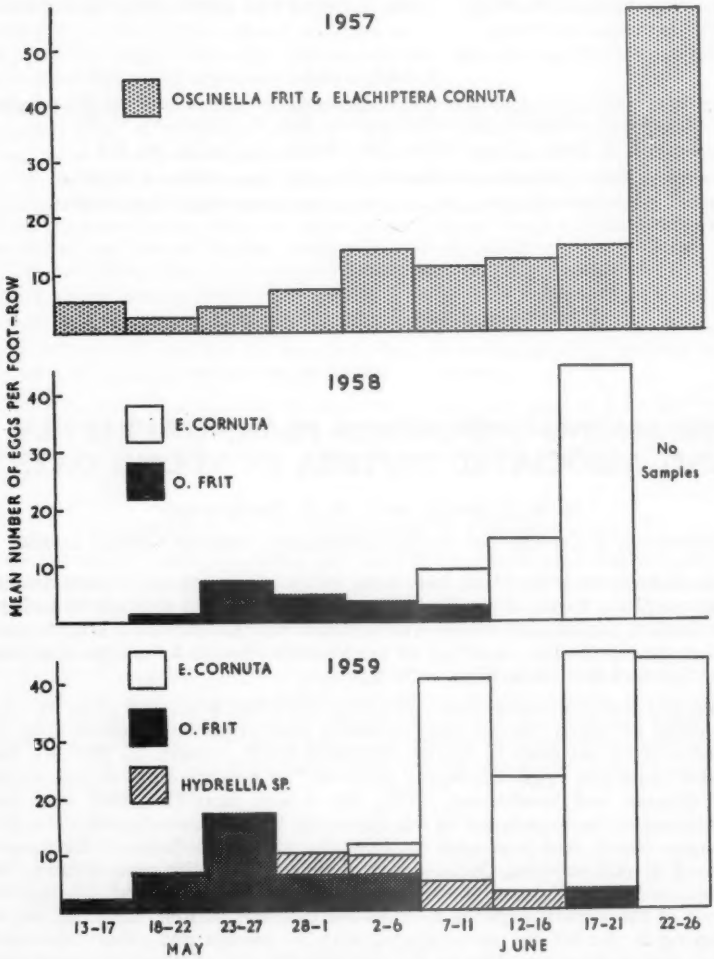


Fig. 1. Numbers of frit and "frit-like" eggs found in grab samples from young oats in each five-day period from May 13 to June 26. The numbers of foot rows sampled in 1957, 1958 and 1959 were 59, 42 and 50 respectively.

Small numbers of adults of other Chloropids have also been found in the oatfield; they were *Oscinella posticata* Collin, *Conioscinella frontella* Fall., *Tricimba cincta* Meig., *Aphanotrigonum trilineatum* Meig. and *Tropidoscinis*

albipalpis Meig. The eggs of these species are probably on present knowledge indistinguishable from those of the frit fly; fortunately in our case they were present in such small numbers that we could disregard them; furthermore, they were mostly found after the main frit fly oviposition period.

It seems that there is probably a cause-and-effect relationship between the frit fly and most, if not all, of these other Diptera. Mesnil (1935) states that on the Continent *Elachiptera cornuta* is commonly found in oatfields, its larvae being saprophagous on the decaying "fritted" deadhearts. The same author records *Hydrellia griseola* Fall. as a leaf miner, especially in barley; however, we have often found larvae of a species of *Hydrellia* when washing soil and debris from around the base of oat plants infected by the frit fly.

In conclusion, therefore, the first wave of egg laying in young spring oats is that of the frit fly. This is followed by a second and much larger peak of eggs of *E. cornuta* and various other Diptera, which are mostly saprophagous on the deadhearts produced by the frit larvae; the eggs (and young larvae) of these flies are very similar to those of the frit fly. Under the conditions at Sunninghill, frit fly oviposition is mostly in May, and that of the saprophagous species in June.

This work is part of the programme of research on insect ecology sponsored by the Agricultural Research Council. We are grateful to Mr. H. F. van Emden for assistance with the sampling in 1959.

REFERENCES

JEPSON, W. F. and SOUTHWOOD, T. R. E. (1958). Population Studies on *Oscinella frit* L. *Ann. appl. Biol.*, **46**, 465–74.

JEPSON, W. F. and SOUTHWOOD, T. R. E. (1960). The Recognition of the Immature Stages of *Elachiptera cornuta* (Fallen) (Diptera, Chloropidae) with Notes on its Association with *Oscinella frit* (L.) in Oatfields. *Proc. R. ent. Soc. Lond.* (A). (In the press.)

MESNIL, L. (1935). in BALACHOWSKY, A. and MESNIL, L. *Les Insectes Nuisibles aux Plantes Cultivées.* Vol. 1. Etablissements Busson, Paris.

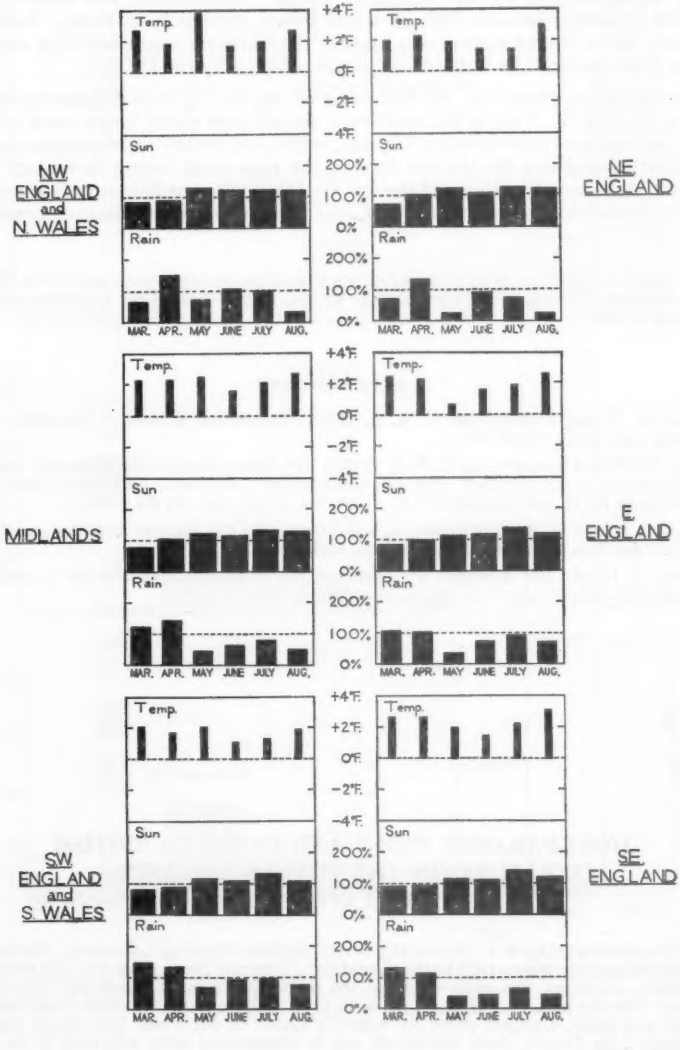
RIGGERT, E. (1935). Zür Kenntnis der Lebensgewöhnheiten von *Oscinella frit* L. und ihrer Jugendstadien. *Arb. physiol. angew. Ent. Berl.* **2**, 110–30.

HOST-PARASITE INDEX AND GUIDE TO BRITISH LITERATURE ON THE FUNGUS DISEASES OF CULTIVATED PLANTS

British Parasitic Fungi, by W. C. Moore, Director of the Plant Pathology Laboratory, Harpenden, was published in November 1959 by the Cambridge University Press, price 45*s*. The book contains 430 + xvi pages, 8vo, with one map. The matter is presented in two parts for ease of reference. The first part, on "Hosts", pp. 3–47, is an alphabetical index of the fungi recorded on each host plant, arranged under the scientific names of 402 hosts. The second part, on "Parasites", pp. 51–430, deals individually and in alphabetical order with each of the 1,483 parasitic fungi. References are given to first and other important descriptions, followed by a separate paragraph for each plant disease caused by the fungus, with particulars of its distribution and prevalence. Annotated references are given to the British literature.

MARCH – AUGUST WEATHER 1959

Variations from Average



THE WEATHER OF ENGLAND AND WALES*

SPRING AND SUMMER 1959

WINTRY weather in 1959 came to an end in mid February and much of the March weather was mild with a lot of rain in the south; drier conditions prevailed in the north. There was an absence of severe frosts. The mild wet weather continued into April, with fairly frequent thunderstorms for the time of the year. There were remarkably few air frosts, and growing conditions were, on the whole, good. The last month of the spring quarter heralded the onset of one of the outstanding summers of the century. May was everywhere warmer than normal, with day maxima over 80°F on the 11th. It was also the driest May since 1953 and sunshine was plentiful.

Warm sunny weather continued in June; most areas were dry although some western districts had normal rainfall. Thunderstorms were widespread around the 24th and 25th but were not otherwise prevalent. The July weather was similar although there was a temporary breakdown in the generally fine weather between the 25th and 27th, when thundery rains affected a broad strip of the country from Dorset to Norfolk. The following August maintained the sunny warm conditions apart from temporary breaks near the middle of the month. Apart from local storms, dry weather again prevailed especially in the East Midlands.

The weather for each of the six months, March to August inclusive, is represented graphically on page 36. Figures for the six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall. The outstanding feature is the prevailing warmth; all areas had average temperatures above normal in every month. The other important factors are the high sunshine averages—it was probably the sunniest summer for many years—and the four months semi-drought conditions. Taken as a whole, the current half-year has much in common with 1921, with the exception that 1959 followed a long wet period and 1921 preceded one.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

***Schreckensteinia festaliella* Hübn. Damaging Cultivated Raspberries.** Morison (*Trans. R. Highl. Agric. Soc. Scot.*, 1953, **65**, 64–5) gives a brief review of this microlepidopteran which causes annual damage to wild raspberries in N.E. Scotland. Damage by the larvae does not appear to have been recorded in Britain on cultivated raspberries. On August 2, 1959, several young canes in a spawn bed (var. Malling Jewel) at Fochabers, Morayshire were noted to be damaged, and larvae were found feeding on the upper epidermis of the leaves. About ten yards from the damaged canes were several wild raspberry canes which were similarly damaged. In both cases damage was slight and could not be considered economically important. In the laboratory, larvae fed on the following varieties: Malling Jewel, Malling Enterprise, Malling Promise, Malling Exploit, Norfolk Giant, and Lloyd George.

M. W. SHAW

* These notes and the diagrams on page 36 are provided by the Agricultural Branch of the Meteorological Office, and are published by permission of the Director-General.

***Gottholdsteineria buxophila* Attacking Box Hedges.** Two cases of damage to box (*Buxus sempervirens*) hedges in gardens in Aberdeen have been investigated, and both yielded numerous specimens of the spiral eelworm, *Gottholdsteineria buxophila* (Golden). Both hedges showed top symptoms: yellowing of the leaves, dying stems, and some completely dead plants. One of the hedges was probably planted when the garden was laid out in 1938, and the other is at least ten years old. This nematode has not been previously recorded from the north of Scotland, but it is probably widespread, since the symptoms are commonly seen and attributed to old age or frost.

G. M. MACKINTOSH

Bulb and Potato Aphid in Northants. Throughout the dry summer months of 1959, several maincrop potato fields on the strong clays near Oundle were infested with subterranean colonies of *Rhopalosiphoninus latysiphon* Davids. In addition to the usual symptoms of damage described by Legowski and Gough (*Plant Pathology*, 1953, **2**, 126–30), we noted that small colonies were frequently established on the tubers, the skins of which were quite wet in the feeding area. While the tissues underlying these moist patches appeared normal and were not collapsed, it seems possible that the aphid punctures could provide a means of entry for secondary organisms. The varieties affected were: King Edward, Majestic and Record, and the yield loss was estimated at 2–3 tons per acre.

R. GAIR and D. E. CUMMINS

Downy Mildew of Soya Bean. During the summer of 1959 a downy mildew was found on soya bean, variety Bansei, being grown for seed in Suffolk. The identity of the fungus, *Peronospora manshurica* (Naum.) Syd., was confirmed at the Plant Pathology Laboratory, Harpenden. The soya beans were in two plots, over a mile apart, one of four 55-yard rows sown in mid April, and the other of two 60-yard rows, sown in late May 1959. Growth in both was delayed by attacks from rabbits. No infection had appeared in the May-sown plots by mid October, when the plants were 24 inches high and in pod. On the April-sown plot infection was first noticed in late August, when the plants had three to five branches averaging 30 inches high, and a few were beginning to flower. By early September the attack had become severe, with 95 per cent of the plants affected over 20 yards at the ends of the plot, but with about 3 per cent affected in the centre. There was only slight further spread by mid October. The lesions appeared as bright yellow spots, mostly 3–7 mm. diameter, on the upper surfaces of the outer leaflets. On the lower surfaces the spots were often covered with a grey downy growth of sporangiophores. Infection was confined to the leaf laminae, and was not seen on the stems, petioles or bean pods. Another, less vigorous variety, Panda, growing 100 yards away from the infected crop, remained free from attack. This is the first time that *Peronospora manschurica* has been reported in this country. Infection is thought to have come in with the seed from the U.S.A., where the disease is general in some regions, but tests at Harpenden on a small quantity of the unsown seed failed to confirm seedborne infection.

T. KINGSLEY

ADDENDUM

Vol. 8 (Part 4) December 1959

P.121. Add footnote: "Phosdrin" is a Shell registered trade mark for an insecticidal product containing 2-methoxycarbonyl-1-Methyl vinyl-dimethyl phosphate.

(78718) Wt. 26 K 9 3/60 Hw.